BOTANICAL SURVEY OF SOUTH AFRICA

MEMOIR No. 5

Researches on the Vegetation of Natal

SERIES I

INCLUDING ACCOUNTS OF INVESTIGATIONS ON

(1) The Measurement of the Size of the Aeration System of the Leaves of certain Natal Plants by an Injection Method

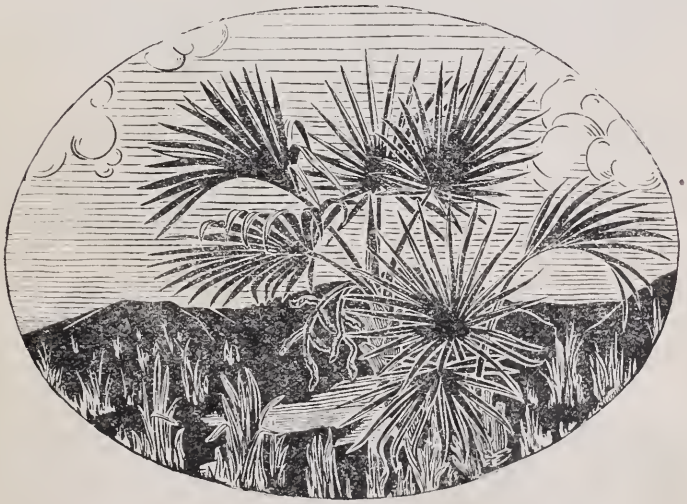
(2) A New Calcium Chloride Method of Measuring the Resistance of Leaves to Water-Loss

(3) The Measurement of Light Intensities in South Africa with Special Reference to Plant Habitats

(4) The Rate of Water-Loss during the Drying of Leaves

(5) The Distribution and Ecology of the Genus *Cussonia* (Thunb.)

By J. W. BEWS, M.A., D.Sc., and R. D. AITKEN, M.Sc.



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To the Director,

Union Botanical Survey.

Dear Dr. Pole Evans,

The following pages include an account of some of our work with the M.Sc. classes in botany at the Natal University College during the last year or two. The various investigations were primarily intended to supply a training in research methods to the students concerned. Among others, Mr. G. W. Gale worked on "Intercellular Space Systems"; Mr. F. N. Howes on "Resistance to Water-Loss," Mr. L. P. McGuire on "Light Intensities"; Mr. P. Hardaker on "The Rate of Water-Loss during the Drying of Leaves." Mr. Gale was assisted by a Union Government Research Scholarship, and for a paper, of which our chapter on the aeration system of leaves is only a slightly condensed account, he was awarded the Cornwall and York prize by the Vice-Chancellors' Committee of the South African Universities. We have to thank Professor Thoday also for certain suggestions with regard to Gale's work.

While I am myself responsible for the general plan and initiation of the various researches, they owe much to Mr. R. D. Aitken's careful supervision throughout. He has also included in this joint memoir some unpublished work of his own on *Cussonia*.

Investigations begun by other students during 1921-22 are not yet completed, and further work of a similar nature is in progress with the help of this year's class. I hope therefore that this will be the first of a series of researches on the vegetation of Natal which will help forward our scheme for the Botanical Survey of the Union.

I am,

Yours faithfully,

(Sgd.) J. W. BEWS.

Natal University College,
Pietermaritzburg, 31st March, 1923.

Division of Botany,
Pretoria, 11th October, 1923.

Sir,

I have the honour to transmit herewith for publication the manuscript of papers submitted by Prof. J. W. Bews, of the Natal University College, Maritzburg, Natal. As you will see from the covering letter from Prof. Bews, the papers are the outcome of pieces of research work undertaken by some of his senior students.

I have the honour to be, Sir,

Your obedient servant,

I. B. POLE EVANS,
Director, Botanical Survey of South Africa.

To the Secretary for Agriculture,
Pretoria.

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Researches on the Vegetation of Natal.

SERIES I.

SECTION I.

The Measurement of the Size of the Aeration System of the Leaves of Certain Natal Plants by an Injection Method.

Introduction.

The importance of the aeration system in plants as the path of gaseous diffusion and of water loss has long been recognized, but comparatively few attempts appear to have been made to determine accurately the comparative size of the system in plants of various types. Sachs, in his well-known "History of Botany" (4), refers to the work of Christian Wolff (1721), who injected leaves by placing them in water under an air-pump, and Wolff's pupil, Thümmig (1723), carried out similar experiments on certain plants. The first extensive application of this method to the determination of the size of the intercellular space system of leaves was made in 1854, when Unger carried out a large number of experiments on various species chosen apparently more or less at random. Haberlandt (2) summarizes what may be regarded as the modern position, based presumably on a study of the intercellular spaces by means of leaf sections. He regards increase of aeration system in leaves as a response to hygrophilous conditions and decrease as an adaptation to a xerophytic environment. "In plants which are forced to reduce their transpiration in order to avoid the danger of excessive loss of water, the spongy parenchyma is comparatively small in amount and scantily provided with intercellular spaces. . . . In the case of plants inhabiting damp, shady situations or more generally whenever the nature of the environment tends to lower the rate of transpiration, it is necessary that actively transpiring tissues should be plentifully developed. As Areschoug has pointed out, leaves in which the mesophyll is entirely made up of spongy parenchyma should be regarded in the main as extreme cases of this hygrophilous adaptation." In this connection it should, however, be remarked that the evaporation of water is not the only process taking place within the intercellular spaces. They also provide the pathway for the equally, if not more, important processes of gaseous exchange. Consequently, there would appear to be some ground for questioning whether the relationship between the intercellular space system and the conditions affecting transpiration is quite as simple and direct as the above statement implies.

McLean (3), in an interesting account of his studies in the ecology of tropical rain forest, has compared the intercellular space-systems of the leaves of twelve species—six sun-loving and six shade-loving. He found that the average amount of fluid absorbed after injection by unit weight of the leaves was: Sun-leaves 16.3 per cent., shade-leaves 29.8 per cent. He does not state whether his results were obtained from single leaves only, nor what the variation between different leaves of the same plant or same species was. One of his sun-leaves (*Cycas*) gave the figure 29.8 per cent., another (*Rosa*) 26.5 per cent., while one of his shade-leaves (*Tradescantia*) gave only 8.6 per cent. He makes no mention of any difficulty in obtaining complete injection (though our own experience is that this is often considerable) and one may suspect that the low result for *Tradescantia* was due to this cause. At any rate, the number of observations made by McLean were too few to enable any very definite conclusions to be drawn. He compares his figures with those of Unger, and finds the average 20.55 per cent. strikingly close to that obtained by the latter; and concludes this portion of his paper with the somewhat remarkable statement that "nothing could better illustrate the uniformity of structural type in the Angiosperms than the correspondence of these figures, obtained in localities so far apart and from plants of environments so different in many important respects."

The present investigation was begun with the primary object of throwing light on certain ecological problems. The underlying idea was to compare the intercellular space systems of species which are important in the local plant successions, but, unfortunately, it was found impossible to obtain accurate results, or indeed any at all, for certain important types, and consequently the results of the investigation are, from this point of view, somewhat incomplete. It was early realized that the method itself required critical investigation before the results obtained could be regarded as trustworthy, and a considerable amount of time was devoted to this preliminary investigation. The present paper is therefore divided into two sections: (1) On the method of experiment and the expression of results; and (2) on the intercellular space systems of the leaves of various Natal plants.

I.—The Experimental Method and the Expression of Results.

A.—The Method.

The intercellular space systems of leaves is estimated by simply injecting them under reduced pressure with fluid of known specific gravity. The leaves are weighed and placed in a conical filter flask, the side exit of which is attached to an air-pump. The tube of a large dropping funnel, which contains the injection fluid, passes through the cork at the top of the flask. Air is exhausted from the flask by means of the pump, and this also withdraws the air from the intercellular spaces of the leaves. The stop-cock of the funnel is now opened, and fluid run in from the reservoir until the leaves are completely covered. A few more turns of the air-pump are necessary to exhaust the air dissolved in the injection fluid. The flask is now disconnected from the pump, and, as air rushes in, the injection fluid is forced into the leaves. These are then carefully dried and weighed; the increase in weight divided by the specific

gravity of the injection fluid gives the volume of the intercellular space system. Acting on McLean's suggestion, 4 per cent. alcohol in water (specific gravity 0.99) was used as the injection fluid; "it is too weak to cause any shrinkage of the cells, but possesses a much lower surface tension than pure water, and hence penetrates more easily."

The process of injection can actually be observed in most leaves, and thus there is a guarantee that injection shall be complete. Similarly, drying out of the fluid from the intercellular spaces can be observed, and as this takes place fairly rapidly once the leaf surface has been dried, it is necessary to weigh the leaves immediately after drying them. On this account it was decided to use single leaves or leaflets for each measurement. The surfaces of the leaves dry readily on wiping with a linen cloth, but care must be taken not to force out any of the fluid from within.

Different types of leaves inject at different rates and with varying degrees of difficulty. Unless the surfaces of the leaves are wetted, air, and not the injection fluid, rushes into the intercellular spaces, when the pressure is increased by disconnecting the flask from the air-pump. Some leaves do not wet readily, and thus the injection process is rendered difficult: the only remedy seems to be to shake the contents of the flask as the air rushes in. In these cases it is generally necessary to repeat the whole process one or several times before the injection is complete. In all cases it was found that injection was far more rapid when slits were previously cut in the surfaces of the leaves, and in many cases this is essential in order that injection may take place at all.

The precise relation, if any, between internal leaf structure and ease of injection was not arrived at. It was observed that, generally speaking, thin leaves are more difficult to inject than thicker ones and leaves with a fine reticulate venation (e.g. *Ptaeroxylon utile*) than those with a few prominent veins and excessively fine venation between (e.g. *Ficus capensis*). Certain leaves which nearly all possess a thick cuticle defy all attempts at complete injection (e.g. *Zizyphus mucronata* and *Heteromorpha arborescens*). Parallel veined leaves will not inject—a fact which has the unfortunate effect of excluding from our investigation the very important ecological types among the Gramineae. Leaves with a covering of hairs are useless for injection purposes, as it is impossible to dry them, the hairs holding the fluid by capillary action.

B.—Critical Investigations on the Method.

During investigations on the method itself and upon the purely physiological problems which were opened up by the difficult question of how to express results, attention was more or less confined to three different species, each representing a definite ecological type. *Podocarpus henkelii* is the most mesophytic of the three species of yellowwood known in Natal and is the climax and dominant species in many of the forests of the southern Drakensberg. *Portulacaria afra* (the spekboom) is a typical pioneer species of the low veld, often acting as a pioneer of river valley scrub, e.g. along the Fish River. The fleshy, succulent leaves of this plant afforded some very interesting results. *Ptaeroxylon utile* (the sneezewood) is somewhat variable in

its ecology, occurring both in high veld and in low veld, growing in the open or in dense bush. Its leaves are pinnately-compound, and the leaflets were used as the units for experiment.

Unless otherwise stated, results of injection experiments are expressed as a percentage ratio of volume (in c.c.) of fluid injected to live weight (in gms.) of the leaf immediately prior to injection. It is perhaps as well to anticipate a little and to state that the volume of fluid injected is not necessarily a measure of intercellular space volume.

1.—*The Rôle of Stomata during Injection.*

Experiments were performed on leaves of *Ptaeroxylon utile* and of *Podocarpus henkelii*. In the first experiment, freshly picked leaves were used and were divided into two sets, those in which slits were cut and those in which they were not. In the second experiment, leaves which had been drying for five hours were used and divided into two groups, as in the previous experiment. The results of these experiments are tabulated below.

A.—With *Ptaeroxylon utile*:—

(i) Freshly picked leaves—
  (*a*) Injection by ordinary process; slits cut in leaf, 16.01 per cent.
  (*b*) Injection by ordinary process; *no* slits cut in leaf, 15.82 per cent.
    In (*b*) injection took place less rapidly than in (*a*), but was complete and must have occurred through stomata.

(ii) Leaves which had been drying out for five hours—
  (*a*) Injection by ordinary process; slits cut in leaf, 15.72 per cent.
  (*b*) Injection by ordinary process; *no* slits cut in leaf, nil.
    In (*b*) no injection took place at all owing to the fact that the stomata were closed.

B.—With *Podocarpus henkelii*:—

(i) Freshly picked leaves—
  (*a*) Injection by ordinary method; slits cut in leaf, 35.72 per cent.
  (*b*) Injection by ordinary process; *no* slits cut in leaf, nil.

(ii) Leaves which had been drying out for 25 hours—
  (*a*) Injection by ordinary method; slits cut in leaf, 39.8 per cent.
  (*b*) Injection by ordinary process; *no* slits cut in leaf, nil.

These experiments afford sufficient evidence to show that when the stomata remain open they allow the injection fluid to enter the leaf, as is the case with freshly picked leaves of *Ptaeroxylon utile*. The failure of *Podocarpus* leaves to inject, even when freshly picked, unless slits were cut, indicates that the stomata are closed. This suggests either that the stomata close almost immediately the leaf is detached from the twig or that the guard cells collapse under the reduced pressure. In any case, even when the stomata do not remain

open, cutting slits in the leaf makes the injection process more rapid, and this procedure was consequently followed in all the succeeding experiments.

2.—*Loss of Weight due to Evaporation under Reduced Pressure.*

During the course of experiment, the leaves used are placed under reduced pressure for about five minutes in order to exhaust the air from the intercellular spaces preparatory to injection. It might be objected that during this time a considerable amount of water is lost from the leaves, and thus the gain in weight due to the filling up of the air spaces by the injection fluid is partly neutralized and too low a result obtained. This point was tested by treating some leaves just as in an ordinary experiment, but reweighing just before the stage at which the injection fluid is added. A slight decrease in weight was noted, amounting to barely 1 per cent of the live weight. There is, therefore, a slight error from this source, but, as will be seen later, any such loss of weight is doubtless made up by reabsorption when the injection fluid is introduced.

3.—*Absorption of Injection Fluid by the Cells of the Leaf.*

The error due to this cause may often be very considerable, so much so that it was discovered to be absolutely necessary to conduct experiments under conditions which precluded the possibility of its occurring; the point will be fully dealt with in the following section.

C.—*Method of Expression of Results and the Relationship of the Apparent Intercellular Space System to the Water-Content of the Leaf.*

Dealing only with mature leaves chosen from similar situations on each of the three trees mentioned above, a series of experiments was begun and continued over a period of three months. Expressing the results obtained as a percentage ratio of volume of fluid (in c.c.) entering the leaf during injection to live weight (in gms.) of the leaf immediately prior to injection, a remarkable range of values was obtained.

Podocarpus henkelii gave values ranging from 24.73 per cent. to 61.72 per cent.; *Portulacaria afra* from 21.04 per cent. to 73.43 per cent.: *Ptaeroxylon utile* from 15.59 per cent. to 56.62 per cent. These results, however, are not to be interpreted as implying so extensive a range in the absolute amount of intercellular space in the leaves. The clue to their true interpretation was gained from the fact that high results were obtained during hot dry weather and low results during rainy weather. The investigations were begun in August, which, coming as it does at the end of the Natal winter, marks the time at which the water-content of the soil and of the plants is at its lowest, and, continued into the summer, when heavy rains lead to a great increase of water-content. Thus, a sharp contrast between results obtained at the two different seasons was presented and could not fail to arrest attention. In the first place, it must be remembered that the intercellular space volume is expressed as a percentage ratio to the live weight of the leaf, and that variation in a ratio may be due to variation in the consequent term as well as in the antecedent. The live weight of the leaf does, of course, vary, chiefly according

to its water-content. A decrease in water-content will therefore lead to a high result in the experiments under discussion; hence the high results in dry weather and the low results in wet weather. Indeed, assuming for the moment that the relative amount of intercellular space is the same for leaves in similar situations on the same tree, the present method becomes a novel one for measuring variations in the water-content of leaves. In this connection the following results are interesting: —

TABLE I.

	Portulacaria afra.	*Ptaeroxylon utile.*	*Podocarpus henkelii*
Expt. I.—Sept. 1—Hot dry wind..	73·43 %	54·30 %	61·72 %
	48·62 %	47·72 %	57·44 %
Hot weather continuously till Sept. 7, when rain all day.	62·21 %	50·49 %	59·81 %
Expt. II.—Sept. 6—Cool, no rain...	31·42 %	19·68 %	48·45 %
	31·61 %	18·33 %	46·09 %
Expt. III.—Sept. 13—After several days' continuous rain...	29·13 %	12·23 %	31·82 %
	27·54 %	11·91 %	33·83 %
Expt. IV.—Average results of experiments with fully turgid leaves.....	22·38 %	10·00 %	19·78 %

The figures above indicate clearly enough that *Portulacaria afra* responds fairly rapidly to changes in soil humidity, *Ptaeroxylon* less rapidly, and *Podocarpus henkelii* very slowly, although even in Experiment III not one of the three is down to its average for fully turgid leaves. It is doubtful, of course, whether in nature the condition of maximum turgidity is ever attained by leaves of plants in open habitats. Seeing that the trees from which the above results were obtained were growing within a few yards of each other, it seems safe to conclude that the different response in each case is due to differences in the conducting power of the wood—the gymnospermous wood of *Podocarpus* having the least conducting power, and so on. This again suggests another line of research—a comparison of the conducting power of the woods of our indigenous trees by the method of Farmer, recently applied by Aitken to *Pinus* and *Leucadendron* in the Cape Peninsula (1). The present results show how, owing to having wood of low conductivity, the leaves of a tree may actually be under "xerophytic" conditions (temporarily, it is true) in a saturated atmosphere, all of which goes to indicate the great complexity of physiological problems, especially those dealing with water relationships.

Since the live weight of the leaf is, therefore, subject to considerable variations, it will not serve as a standard to which to refer intercellular space-content, particularly when we wish to note variations in the latter quantity. Some other standard had to be found, and at first it seemed as though the volume of the leaf might serve. The determination of leaf volume presented some difficulty; eventually, the simplest method proved the best, and the leaves were weighed, after injection, under water, the loss of weight in grammes being equivalent to the volume in cubic centimetres. It was generally necessary to use a sinker. Calculated as a percentage of leaf volume, the figures for intercellular space-content do not vary as much

as when expressed as a percentage of live weight. The following figures for *Ptaeroxylon utile* clearly demonstrate the point:—

Table II.

Ratio of fluid absorbed (c.c.) to live weight (gms.) to leaf volume.

Same leaf used in order to obtain the two values in each case....	53·36 %	31·78 %
	56·62 %	33·09 %
	29·10 %	29·53 %
	28·72 %	29·20 %
	43·86 %	34·27 %
	45·13 %	34·89 %

Nevertheless, variations do still occur which it is fairly clear are correlated with conditions of humidity. Professor Thoday, in dealing with *Helianthus* has shown that there are considerable variations in superficial leaf area, due to varying conditions of light intensity and water-content (5). Hence we may conclude that there are also variations in leaf volume; and whatever their magnitude, they will tend to obliterate or disguise variations in a quantity (the intercellular space-content) expressed in terms of leaf volume.

At this point it becomes necessary to consider the possibility that the volume of fluid absorbed during injection may not simply fill the intercellular spaces, but that some of it may be absorbed by the cells of the leaf. Experimental tests were carried out with leaves of the three species dealt with hitherto; leaves were weighed, slits cut in them, and they were placed in the injection fluid for five minutes (the length of time for which they remain in the fluid during injection) then reweighed. A slight increase in weight was noted in every case, equivalent to about one-half per cent. of the live weight.

This result tempts one to say that absorption is therefore practically nil, but it must be remembered that in these experiments absorption can only take place through the cut end of the petiole, edges of slits, cuticle, and as vapour by the cells of the internal mesophyll; whereas during injection all the internal surface of the leaf is in direct contact with the injection fluid. Although the leaf is only immersed a few minutes, there is undoubtedly time enough for a considerable amount of water to be absorbed. The presence of alcohol, of course, gives the solution a high osmotic pressure, but alcohol itself penetrates so rapidly that its osmotic pressure does not count for more than a fraction of its theoretical value, which, in this case is 15½ atmospheres. Experiments made with plasmolysed cells of *Nitella* and *Spirogyra* showed that even in 4 per cent. alcohol, recovery took place within five minutes, thus showing how rapid absorption may be.

As it is quite impossible, under the conditions of the experiments, to determine quantitatively the amount of injection fluid absorbed by the cells of the leaf, the only method of arriving at a correct quantitative estimate of the amount of intercellular space only, is to prevent absorption altogether. This can only be guaranteed by rendering the cells of the leaf fully turgid, which was done by placing twigs of the plants to be dealt with in water and under a bell-jar and not experimenting until drops of water began to appear on the sides of the bell-jar and on the leaves. This method not only has the advantage of preventing absorption of the injection fluid by the cells of the leaf, but it also enables us to compare leaves of the same and of different species under identical conditions, viz., those of maximum

turgor. The whole volume of the fluid injected then represents intercellular space-volume, and the live weight of the leaf is at a maximum in every case with which we henceforth deal.

The practical importance of dealing only with leaves that are fully turgid is clearly demonstrated by the following series of figures for *Gardenia* sp.:—

TABLE III.

Freshly picked twig	18·48 %	14·47 %	18·81 %
Same twig after having been in water (open to the air) for one hour..	13·31 %	11·18 %	10·67 %
Same twig kept in water (under a bell-jar) for twenty-four hours ..	9·42 %	9·46 %	11·41 %

In the light of evidence adduced in this section it is possible that the work of both Unger and McLean is open to criticism which may seriously invalidate their results and the conclusions they draw from them. The writers were not able to consult Unger's paper, but in McLean's account of Unger's work and of his own, no mention is made of the precautions necessary to ensure that the cells of the leaf shall be fully turgid before injection occurs. Unless these precautions were taken, it is very probable that their results were all too high, although it is only fair to mention that Unger's work was carried out in a temperate climate and that of McLean in tropical rain forest; in the latter case it would be safe to assume that the leaves dealt with were probably fully turgid.

In connection with the foregoing work it has been suggested that there is some correlation between amount of fluid injected and water-content of the leaf. To test this supposition, three series of carefully conducted experiments were made, the results of which are given in Table IV. In each series a twig of the plant was taken from the tree and leaves of it injected immediately. Then the twig was divided, one-half being allowed to dry out and the other being placed in water under a bell-jar. At the intervals stated, leaves were taken from each half of the twig and injection experiments made on them. The dry weight of each leaf was determined as a percentage of its original live weight. In the following table each percentage given represents the average of three experiments:—

TABLE IV.

A. *Podocarpus henkelii*.	1. Fluid Injected per cent. Live Weight.	2. Water-Content per cent. Live Weight.	3. Dry Weight per cent. Live Weight.	4. Assuming Dry Weight 45·5 per cent. in all cases. Water-Content.	5. Injection.	6. Water-Deficit.	7. Excess Injection.
After drying out 67¾ hours.....	61·3	32·4	67·6	21·8	41·3	22·7	19·6
After drying out 27¼ hours.....	48·0	44·4	55·6	36·4	39·3	18·1	17·6
After drying out 19¼ hours.....	47·2	43·9	56·1	35·6	38·3	18·9	16·6
Fresh picked leaves.....	29·6	50·8	49·2	46·9	27·4	7·6	5·7
In saturated atmosphere 19¼ hours	21·7	54·5	45·5	54·5	21·7	0	0
In saturated atmosphere 27¼ hours	21·7	54·5	45·5	—	—	—	—

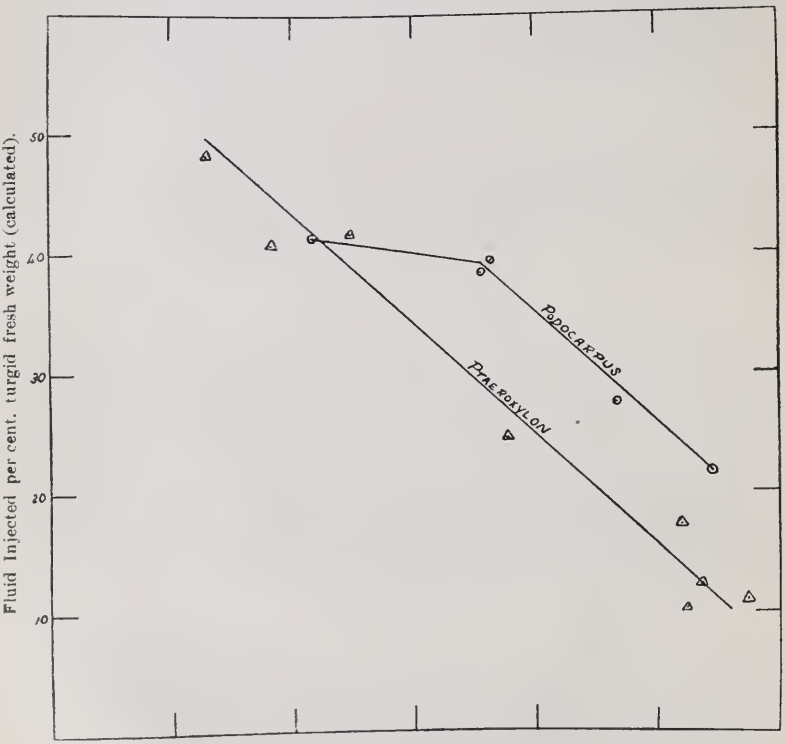
B.—*Ptaeroxylon utile.*	1. Fluid Injected per cent. Live Weight.	2. Water-Content per cent. Live Weight.	3. Dry Weight per cent. Live Weight.	4. Assuming Dry Weight 42·6 per cent. in all cases. Water-Content.	5. Injection.	6. Water-Deficit.	7. Excess Injection.
After drying out 95½ hours.....	86·6	23·35	76·65	13·0	48·2	44·4	37·2
After drying out 77¾ hours.....	68·8	30·0	70·0	18·3	41·8	39·1	30·8
After drying out 24¼ hours.....	63·1	36·9	63·1	24·9	42·6	32·5	31·6
After drying out 5 hours.....	30·3	47·6	52·4	37·8	24·6	19·6	13·6
Fresh picked leaves.....	18·1	55·0	45·0	52·0	17·1	5·4	6·1
In saturated atmosphere 4¾ hours.	12·8	56·0	44·0	53·7	12·3	3·7	+ 1·3
In saturated atmosphere 23¼ hours	10·7	55·2	44·8	52·4	10·2	5·0	- 0·8
In saturated atmosphere 100¼ hours	11·0	57·4	42·6	57·4	11·0	0	0

NOTE.—We are indebted to Professor D. Thoday, M.A., for suggesting the above method of expressing these results.

C.—*Portulacaria afra.*	1. Fluid Injected per cent. Live Weight.	2. Water-Content per cent. Live Weight.	3. Dry Weight per cent. Live Weight.	4. Assuming Dry Weight 9·46 per cent. in all cases. Water-Content.	5. Injection.	6. Water-Deficit.	7. Excess Injection.
After drying out 314 hours.....	63·5	88·95	11·05	76·0	54·3	14·55	34·0
After drying out 270½ hours.....	35·5	89·8	10·2	83·1	32·9	7·45	12·6
After drying out 194 hours.....	45·5	90·45	9·54	93·7	45·2	+ 3·15	24·9
After drying out 169¾ hours.....	35·4	90·7	9·27	92·5	36·1	+ 1·95	15·8
After drying out 122¼ hours.....	28·1	90·7	9·31	92·0	28·5	+ 1·45	8·2
After drying out 96¼ hours.....	32·5	90·7	9·31	92·0	33·0	+ 1·45	12·7
After drying out 50½ hours.....	31·2	91·4	8·58	101·0	34·4	10·45	14·1
After drying out 31½ hours.....	30·5	91·4	8·57	101·0	33·7	+ 10·45	13·4
After drying out 24¾ hours.....	32·5	91·1	8·91	96·7	34·5	- 6·15	14·2
After drying out 6½ hours.....	34·9	91·6	8·41	102·8	39·2	+12·25	18·9
Fresh picked leaves.....	32·6	90·6	9·41	91·1	32·8	+ 0·55	12·5
In saturated atmosphere 4½ hours.	32·9	90·3	9·7	88·0	32·0	- 2·55	11·7
In saturated atmosphere 23¾ hours.	28·7	89·5	10·52	80·6	25·8	- 9·95	5·5
In saturated atmosphere 25¾ hours.	21·2	91·6	8·36	103·5	24·0	+12·95	3·7
In saturated atmosphere 29¾ hours.	25·8	90·7	9·3	92·0	26·2	+ 1·45	5·9
In saturated atmosphere 49¾ hours.	19·2	92·25	7·74	112·5	23·5	+21·95	3·2
In saturated atmosphere 100 hours.	20·3	90·55	9·46	90·55	20·3	0	0

Taking first of all the figures for *Podocarpus henkelii* and *Ptaeroxylon utile*, it will be seen from the first two columns that with decreasing water-content, there is an increase in the amount of fluid entering the leaf during injection, but there is no evidence in these columns that these two quantities are directly proportional. The existence of a real correlation between them becomes clear, however,

when the following considerations are borne in mind. The decrease in weight of drying leaves is due entirely to the decrease in the quantity of water present and not to any change in the dry weight. Consequently, when the water-content is expressed as a percentage of the fresh weight, as in the second column of the table, we have a ratio in which both terms vary. Assuming that in the mature leaves of the same twig the dry weight forms an approximately constant percentage of the fresh weight of the fully turgid leaf—an assumption which we have found to be correct within about 1.0 per cent.—we obtain a better basis for calculation. Making this assumption, the figures for the water-content and for the amount of fluid entering



Section I.—Fig. 1, to illustrate Table IV.
Water-Content per cent. turgid fresh weight (calculated).

the leaf during injection are given in columns 4 and 5. In column 6 is given the percentage by which the water-content of the drying leaf (as shown in column 4) falls below the water-content of the fully turgid leaf; this is termed the "water-deficit." In column 7 is given the excess of injection fluid entering the drying leaf (as shown in column 5) over the amount entering the fully turgid leaf. The fairly close agreement of the figures in the last two columns is at once apparent. It is evident, therefore, that when leaves which are

not fully turgid are used for injection experiments, the amount of fluid entering the leaf is equal to the amount necessary to fill the intercellular spaces plus the amount necessary to restore the turgor of the leaf cells.

The graphical expression of these results, shown in Fig. I, brings out the relationship between water-content and amount of fluid injected very clearly. The former is plotted along the x-axis and the latter along the y-axis. In the case of *Ptaeroxylon utile*, all the results then group themselves about a straight line at an angle of about 45° to the x-axis. Four of the results for *Podocarpus* lie on a similar line, while one is slightly aberrant. This clearly indicates a direct relation between the water-content and the amount of fluid injected, the excess of the latter quantity being approximately equal to the deficit in the former.

In the case of *Portulacaria afra*, the results do not work out with anything like the same regularity. In explanation of this it is suggested that possibly the material is less uniform than in the other two cases, and, therefore, the assumption that the dry weight forms a constant percentage of the turgid weight of the leaves is unjustified. As a matter of fact, certain figures in our possession indicate that this percentage varies by about 1 per cent., which is about the same as in the other two cases. Here, however, it must be remembered that the dry weight of *Portulacaria* is less than 10 per cent. of the turgid weight, while that of *Podocarpus* and of *Ptaeroxylon* is over 40 per cent.; consequently the error due to the assumption is four times greater in the one case than in the other two.

Another point of interest may be mentioned here. After drying out for a period of nearly 200 hours, the water content of the leaves of *Portulacaria* had apparently decreased by at most 2 per cent. This suggested at the time that possibly the leaves were not losing all their water during the dry-weight determination; recent work on succulent plants has shown that they form pentoses and pentosans of great water-holding power, requiring prolonged heating at 100° C. to rob them of their last traces of water. In every case, therefore, the leaves were subjected to at least ten hours' drying in a steam oven before their dry weight was determined. It is to be noted that the leaves dealt with remained attached to a twig, and the possibility is suggested that they maintained their water balance at the expense of the stem. The whole question of the water relations of this plant, however, forms the subject of another investigation at present in progress, the results of which will probably elucidate the facts mentioned here.

II.—Leaf Aeration Systems in Certain Natal Plants.

A.—Applicability of the Method to Various Species.

In its applicability to Natal plants the experimental method used during the present researches has limitations. While many interesting and important ecological types are capable of easy investigation, there are others which could not be included. Repeated attempts at injection of grass-leaves met with complete failure, while it is obvious that the Acacias are unsuited to the present method. Another class of leaves—those with hairy coverings—often inject quite readily, but it is quite impossible to dry them. It is interesting to

note how many of the "associated veld plants" have such hairy coverings—e.g. *Helichrysum, Berkheya, Rhynchosia, Hypoxis.* All the genera mentioned were tried without success. Experience in the method by cutting slits in a suitable manner in the leaves may often help in difficult cases; in several, patience is necessary, the leaves only becoming completely injected after four or five repetitions of the experiment.

The information acquired during the research is best set forth under the heading of each species investigated. The species are grouped according to their ecological habitats, except the first three.

Podocarpus henkelii injects readily when slit (not otherwise). Dries easily.

Portulacaria afra injects readily. Care must be exercised when drying not to press out the injection fluid.

Ptaeroxylon utile.—Leaflets used. Not easy to inject unless suitable slits are cut. Dries easily.

High Veld Trees (not pioneers):—

Fagara davyi does not inject readily. Dries readily.

Cassipourea verticillata injects fairly readily. Dries easily.

Podocarpus latifolia injects readily (with slits) and dries easily.

Piper capense.—(Undershrub, always in dense shade); injects very readily; dries easily. Large leaf, hence parts only are used.

Tricalysia lanceolata injects fairly readily. Dries easily.

Olea foveolata injects readily. Dries easily.

Alberta magna injects readily. Dries easily.

Maerua woodii injects readily. Dries easily. Part of leaf used.

Pittosporum viridiflorum.—Injection difficult. Dries easily.

Xymalos monospora.—(Always in dense shade); injection difficult. Dries easily.

Low Veld Trees and Shrubs:—

Gymnosporia buxifolia.—(Often a pioneer); larger leaves inject more readily than smaller ones, although both are difficult. It is difficult to see when injection is complete, and the experiments have to be repeated several times to ensure complete injection. Dries easily.

Combretum sp. (prob. *kraussii*).—(Often a pioneer); difficult to tell when injection is complete, and the experiment is best repeated several times. Drying is difficult, as there is a large hairy covering.

Plectronia spinosa.—(Shrub around margin of clumps of bush); injects fairly readily with suitable slitting. Dries easily.

Gardenia sp.—(Small tree); same remarks as for *P. spinosa.*

Vepris lanceolata.—(Tree); same remarks as for *P. spinosa.*

Randia rudis.—(Shrub at margins of clumps); same as for P. *spinosa.*

Halleria elliptica.—Injection difficult. Dries easily.

Maesa rufescens.—On slitting, it exudes a somewhat sticky juice which renders both injection and drying difficult. It will not inject at all without slitting.

Ochna atropurpurea injects fairly readily. Dries easily.

Cedrela toona.—Not indigenous; same remarks as preceding.

Rhus dentata.—(Shrub at margin of clumps); injects with extreme difficulty, and only one reliable result was obtained. Dries easily.

It was impossible to obtain reliable results with any of the following (mostly associated plants of the low veld), although repeated attempts were made with them:—

Solanum auriculatum.—Dense covering of stellate hairs makes injection difficult and drying impossible.

Heteromorpha arborescens will not inject. A glossy leaf surface which will not wet is probably responsible for this.

Kalanchoe thyrsiflora.—Thick, succulent leaves. It is doubtful whether injection is really complete, reaching the centre of the leaf. Pieces of leaf were used, not whole leaves. Dries easily.

Helichrysum latifolium.—Dense woolly covering on underside, holds water tenaciously, and it is impossible to dry completely.

Hermannia sp.—Prominent veins, frequently branched, form little cavities in which fluid collects and cannot be dried out.

Lactuca capensis.—Milky latex exudes from slits and interferes with injection and drying.

Rhynchosia minima.—Leaflets very small, hairy, and difficult to dry.

Hydrocotyle orbiculata.—Will not inject.

Hypoxis villosa.—Leaves hairy and plicately folded; impossible to dry, although injection takes place fairly readily.

Phœnix reclinata, Moraea sp., Cyperus sexangularis, Eragrostis curvula, and other Gramineae.—In all these, pieces only of the leaves were used. It was impossible to obtain anything like complete injection in any of these parallel-veined leaves.

Water Plant:—

Jussieua repens.—(Floating in quiet pools); injects readily, but has a glossy surface which does not dry easily.

Mangroves:—

Avicennia officinalis.—Injects quite readily. Dries easily.

Rhizophora mucronata.—Injects very readily. Dries easily.

Bruguiera gymnorhiza.—Injects very readily. Dries easily.

B.—Results obtained with Selected Species.

Reliable results have been obtained from experiments on some thirty species of Natal plants. In every case the results were expressed as a percentage of ratio of intercellular space (in c.c.) to live weight (in gms.) of the leaf under conditions of maximum turgor, the latter being ensured in the manner already indicated. In each case (for reasons to be set forth in the next section) leaves from the same tree and same situation on it were used for the determinations on a single species. The results have not been set out at length, but a summary of them is given in the following table.

In Table V we have recorded, under each species, the number of experiments performed, the range (maximum and minimum), the average, and the degree of variability. The latter has been calculated in the following manner: The average value having been obtained, the difference between it and each of the individual results above the average was calculated; the sum of these differences was divided by the number of results above the mean, and the figure thus obtained expressed as a percentage of the average result for the species. This gave the plus degree of variability. The minus degree of variability was calculated in a similar manner. Now if there is an even number of results, half of which lie above the mean and half below, it is obvious that the plus degree of variability will be equal to the minus degree of variability if each is calculated by the above method. This was so in the case of the great majority of the present results. If, however, the results are unevenly distributed about the mean, then two different figures will be obtained. In such cases, where the two results are widely divergent, we have given both; where they are close to each other we have given the greater, and regarded the other as equal to it. The degree of variability has not been calculated for species for which only three or four results have been obtained. The species have been grouped into high veld, low veld, etc., according to the locality from which they came, and graded under these headings according to their degree of variability, those with the greatest being placed at the top.

TABLE V.

Name of Species.	No. of Experiments.	Range.	Average.	Variability.
Podocarpus henkelii	40	25·53 %—16·06 %	19·78 %	± 24·0 %
Portulacaria afra	36	31·46 %—15·02 %	22·38 %	± 37·3 %
Ptaeroxylon utile	54	15·97 %— 7·99 %	10·00 %	± 39·9 %
HIGH VELD TYPES:				
Fagara davyi	8	18·82 %—14·06 %	16·38 %	± 14·6 %
Podocarpus henkelii	9	18·09 %—13·16 %	15·89 %	+11·8 % −5·9 %
Cassipourea verticillata	12	20·61 %—16·58 %	18·59 %	± 10·9 %
Podocarpus latifolia	12	18·91 %—12·25 %	16·10 %	± 10·5 %
Piper capense	12	49·83 %—37·83 %	44·20 %	± 8·6 %
Tricalysia lanceolata	12	25·91 %—18·92 %	22·44 %	± 8·4 %
Olea foveolata	12	85·42 %—68·87 %	77·82 %	± 8·3 %
Alberta magna	6	26·08 %—22·24 %	24·15 %	± 8·0 %
Xymalos monospora	12	50·95 %—39·72 %	44·85 %	± 7·7 %
Maerua woodii	3	42·59 %—39·33 %	41·31 %	—
Pittosporum viridiflorum	2	22·85 %—19·00 %	20·93 %	—
LOW VELD TYPES:				
Gymnosporia buxifolia	12	17·93 %— 5·61 %	14·02 %	± 49·0 %
Combretum sp.	12	30·90 %—16·84 %	23·98 %	± 29·4 %
Plectronia spinosa	12	29·92 %—20·56 %	25·79 %	± 18·2 %
Gardenia sp.	12	12·41 %— 8·62 %	10·23 %	± 9·5 %
Vepris lanceolata	12	32·84 %—27·31 %	29·94 %	± 5·3 %
Randia rudis (shade)	12	17·91 %—16·25 %	16·95 %	± 2·5 %
Halleria elliptica	3	44·86 %—41·11 %	43·56 %	—
Maesa rufescens	3	42·91 %—38·23 %	40·69 %	—
Ochna atropurpurea	3	23·85 %—21·31 %	22·77 %	—
Cedrela toona	3	13·15 %—12·66 %	12·94 %	—
Rhus dentata	1	35·42 %	35·42 %	—
WATER PLANT:				
Jussieua repens	12	51·64 %—42·24 %	46·08 %	± 4·84 %
MANGROVES:				
Rhizophora mucronata	12	25·98 %—21·97 %	23·60 %	± 4·68 %
Bruguiera gymnorhiza	12	32·41 %—30·45 %	31·55 %	+1·32 % −2·27 %
Avicennia officinalis	12	33·81 %—31·03 %	32·25 %	± 1·87 %

C.—Discussion of Results.

Not the least interesting fact which the figures given in the preceding table disclose is the high degree of variability which leaves, even from the same tree, may exhibit. This result is in disagreement with the conclusion arrived at by McLean, that with regard to leaf aeration the Angiosperms exhibit a clear "uniformity of structural type." That his figures, as compared with those of Unger, support this idea can scarcely be regarded as more than coincidence. In the first part of this paper, occasion has been found to urge a possible criticism of the experimental methods of both authors, and hence it is not unlikely that the conclusions drawn from results obtained by their use may be in error.

It is also clear from the above figures that a well-developed intercellular space system is not necessarily a mesophytic character, nor a poorly developed one a xerophytic character, which seems to be the view commonly adopted by many authors, e.g. Haberlandt. It is only necessary to look at the high results obtained for the xerophytic *Portulacaria afra* (22.36 per cent.), *Rhus dentata* (35.42 per cent.), and the mangroves (generally regarded as "physiological xerophytes"), and to compare them with those obtained for mesophytic trees like *Fagara davyi* (16.38 per cent.), *Podocarpus henkelii* (15.89 per cent.), *Cassipourea verticillata* (18.59 per cent.), and *Tricalysia lanceolata* (22.44 per cent.) in order to realize that the relationship is not as simple as is so often supposed. The average for the high veld species, which nearly all came from the interior of mesophytic bush, is 31.1 per cent.; that for the low veld species, which nearly all came from open xerophytic habitats, is 25.1 per cent. The difference between the two averages is not nearly as great as one would expect were it merely a question of "mesophytic" as contrasted with "xerophytic" environment. The amount of intercellular space developed in leaves is doubtless influenced by several factors of which transpiration is only one, even if it be the chief; others which might be suggested are heredity, light intensity, and the functions of assimilation and respiration. Possibly also the degree of soil aeration is another factor influencing the aeration system. This would explain why the mangroves, for instance, growing in a badly aerated substratum, have a high intercellular space-content. A study of the various yellowwoods dealt with also bears out this idea. The average result for a tree of *Podocarpus henkelii* growing in a distinctly mesophytic situation in high veld bush is 15.89 per cent., whereas that for another tree of the same species growing in a far more xerophytic situation in the low veld is 19.78 per cent. The first tree, however, is growing in a well-aerated soil, the second in a badly aerated soil—the difference in soil aeration being one of the most marked distinctions between high veld and low veld. Again, *P. henkelii* is on general grounds undoubtedly a more mesophytic species than *P. latifolia;* yet if we compare the two species growing in the same habitat (viz., Zwaartkop Bush) there is seen to be practically no difference between them with regard to intercellular space development—if anything, *P. henkelii* (15.89 per cent.) is a little lower than *P. latifolia* (16.10 per cent.). This suggests an interesting line of research, to which we shall refer again.

Another commonly accepted idea on this subject which may need to be revised is that sun-leaves have a less amount of intercellular space than shade-leaves. The following table of carefully conducted experiments on sun and shade leaves of *Randia rudis* indicates that the difference only appears when the weight of the leaf is taken as the standard of comparison, but not when the volume of the leaf is taken :—

TABLE VI.

Live Weight of Leaf.	Intercellular Space-Content.	Volume of Leaf.	Result expressed as a percentage of— (1) Weight.	(2) Volume.
(*a*) Sun-leaves of *Randia rudis* :				
·0805 grammes	·010100 c.c.	·0850 c.c.	12·54 %	11·88 %
·0574 ,,	·007676 ,,	·0650 ,,	13·38 %	11·81 %
·0533 ,,	·006262 ,,	·0539 ,,	11·75 %	11·62 %
·0624 ,,	·007675 ,,	·0682 ,,	12·30 %	11·26 %
		AVERAGE...	12·49 %	11·64 %
(*b*) Shade-leaves of *Randia rudis* :				
·0573 grammes	·009797 c.c.	·0795 c.c.	17·10 %	12·32 %
·0400 ,,	·006565 ,,	·0556 ,,	16·41 %	11·81 %
·0435 ,,	·007070 ,,	·0770 ,,	16·25 %	9·18 %
·0459 ,,	·008181 ,,	·0675 ,,	17·82 %	12·13 %
		AVERAGE...	16·90 %	11·36 %

What these figures do indicate is that the specific gravity of leaf substance (excluding air) is less in the shade-leaves in the ratio of $11.36/16.90 = 0.6722$ (shade) to $11.64/12.49 = 0.9322$ (sun), i.e. 72 : 100.

This result again is interesting from the point of view of the physiological anatomy of leaves.

It is, however, the degree of variability exhibited by the various species which is of the greatest interest, particularly when considered in the light of the known ecology of the various species. At this point we should like to make clear why it was that in each series of experiments on a species, leaves were taken from only one tree, and, as far as possible, from similar situations on it. By this means any possibility of variations due to differences in habitat is eliminated, and all variations noted are due to the intrinsic power of the species to vary. It is true that a comparison between different plants of the same species would be of great interest and doubtless give important results, but since from another point of view it was desirable to deal with as many species as possible, time did not permit of the collecting of sufficient measurements for such comparisons. The importance of capability to vary in intercellular space-content will be realized when we remember that it is actually within the intercellular spaces that gaseous exchange takes place between the plant and the atmosphere. Indeed, the intercellular space-system is to plants what the lungs and circulatory system are to animals. Power to vary in intercellular space-content means power to vary in the important physiological functions of transpiration, assimilation, and respiration; and these in their turn are intimately related to the rate of growth, to reproduction, and to other vital processes of the plant.

It may be objected that the degree of variability obtained will depend on the number of experiments performed for each species, increasing as the number of experiments increases. As a matter of fact, we have found that the degree of variability remains more or

less the same, even though the number of experiments is increased. If anything, it tends to decrease; this was particularly the case for the types from the high veld bush and for the mangroves.

Turning now to three species for which the greatest number of results have been obtained, we notice that *Podocarpus henkelii*, which is ecologically a climax type suited to only a narrow range of environment, varies least of the three; *Portulacaria afra*, which is a pioneer species and able to grow in various open habitats, varies considerably more than *Podocarpus henkelii* in its intercellular space-content; while *Ptaeroxylon utile*, which is very adaptable and suited to a wide range of habitats, is the most variable of all.

The conclusion which suggests itself is that climax types in a plant succession are less variable in their physiological structure and functions, and for that reason limited to the stable and often specialized conditions which obtain at the close of a succession or sere; whereas pioneer types are more variable and, for that reason, able to adapt themselves to the more varied, variable, and varying conditions of environment presented during the early stages in plant succession.

The figures obtained for the other species dealt with confirm the view just stated. All the high veld species show comparatively slight variability, being trees or shrubs confined either to climax stages in the succession towards Natal Midland Bush, or else to a specialized habitat within the bush, e.g. *Piper capense*, which is limited to the dense undergrowth, where there is abundant shade. Among the low veld types we notice that the two with the greatest range of variability—*Gymnosporia buxifolia* and *Combretum* sp.—are both pioneers in the establishment of tree-veld, or else appear very early in the succession.

The case of *Jussieua* and the mangroves bear out, to a remarkable degree, the general view already suggested. Here we have four species, each confined to a specialized habitat (water in the case of *Jussieua*, lagoons and brackish water in the case of the other three), which is everywhere very uniform: each of the species has a very low degree of variability, particularly *Bruguiera* and *Avicennia*, even as compared with climax or sub-climax types of closed bush (*Olea foveolata*), etc.

The case of *Podocarpus henkelii*, with a variability of 24 per cent., seems at first sight difficult to fit in with the general conclusion thus advanced, as *P. henkelii* is distinctly a climax type. It is to be noted that the tree from which the measurements were obtained has been grown under artificial conditions, being protected from drought and competition; having now gained a secure hold in what is by no means a natural habitat for the species (an open, exposed situation in the low veld), it is probably able to respond with some degree of success to the varying conditions of its unnatural habitat. After all, probably all plants can vary pretty considerably, given ideal conditions to start with; the point is, could (say) *P. henkelii* vary as readily as (say) *Gymnosporia buxifolia* if both were struggling for possession of an unstabilized habitat, subject to considerable variations of environmental conditions? Probably a more correct

figure for the variability of *Podocarpus henkelii* is to be seen in the second record under the heading of that species in Table V, which represents a tree from the Zwaartkop Bush, or in the allied *P. latifolia.*

Summary and Conclusions.

In the present paper (1) an account is given of previous work on the same subject, and occasion is found later to call some of it into question, (2) a method of estimating intercellular space-content of leaves by injection under reduced pressure with 4 per cent. alcohol is described, (3) critical experiments on the method and on the relation between the amount of fluid absorbed during injection and water-content of the leaf show that it is necessary to work only with leaves whose full turgidity is guaranteed by their having been kept in a saturated atmosphere for some time before experiment, (4) the method of expression of results is fully discussed, and the conclusion is arrived at that the intercellular space-content is best expressed as a percentage of live weight under conditions of maximum turgor, (5) correlative experiments on the power of leaves to absorb the injection fluid and on their relative water-content are described, illustrated graphically, and their possible significance discussed, (6) notes are given on the applicability of the method to over forty species of Natal plants, (7) a table of reliable results is given for twenty-eight species, and the degree of variability of each species is calculated, (8) the results are discussed, being held to indicate that (i) in contrast with the conclusion of McLean, all plants show considerable powers of variation in this particular feature, (ii) in contrast with the views of Haberlandt and Areschoug, a high degree of development of intercellular space is not simply a response to mesophytic environment, but is probably related to other factors as well, among which lack of sufficient soil aeration is possibly an important one, (iii) shade-leaves have in reality no greater development of intercellular space than sun-leaves, although, owing to a difference in the specific gravity of the leaf substances, there may be an apparent difference when live weight is used as the standard in terms of which to express results, (iv) species which appear early in plant successions, i.e. those which are successful in varied and unstable habitats, have a greater degree of variability in their physiological structure and functions than have those which appear later (6).

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SECTION II.

A New Calcium Chloride Method of Measuring the Resistance to Water-Loss in Leaves.

Introduction.

As transpiration, or more generally the loss of water, is a factor of primary importance in the life of all plants, it has for long formed a subject of intensive investigation. Despite this, it is doubtful whether any entirely satisfactory method has yet been devised for measuring the rate of transpiration under natural conditions. The methods most generally employed at present are those in which detached twigs or leaves are used, or those applied to the whole plant, as it grows in its natural habitat or in pots. Of them all, the method of weighing sealed potted plants, to which known amounts of water are added, is probably the only one which really measures transpiration under conditions which approach the normal. Unfortunately, in general laboratory practice it is applicable only to small plants or seedlings.

The use of detached twigs and leaves either for loss of weight determinations or for potometer experiments undoubtedly yields valuable information so long as caution is exercised in the interpretation of results. The recent work of Knight (3) affords an excellent illustration of the extent to which such methods may be employed in the analysis of the processes of transpiration and of wilting. For the purpose of comparing different species, however, the method must be used with very great caution.

Other methods, which may be applied to determining the rate of loss from leaves remaining *in situ*, involve the use of cobalt chloride paper or of calcium chloride. The former, first suggested by Stahl, has recently been considerably improved by Livingstone, and is used by him to measure the intrinsic transpiring power of a leaf at any given temperature (4).

The best known method involving the use of calcium chloride is that described by Detmer in his "Practical Plant Physiology" (2). It consists essentially of placing a leaf under a bell-jar, in which is placed a weighed amount of calcium chloride. The defects of the method have been clearly pointed out by Mrs. Shreve in her "Daily March of Transpiration in a Desert Perennial" (5), and she has sought to remove the principal one by enclosing a dew-point apparatus within the bell-jar, and so making allowance for the amount of moisture originally present in it. As so often happens, however, the greater elaboration of the method renders it more difficult of application, particularly in field studies.

The senior author of this memoir has long had in mind the possibility of using small tubes of calcium chloride as a simple and effective method of measuring the loss of water from leaves while still attached to the plant, and the present investigation aimed at determining the feasibility of this suggestion and the accuracy of the results likely to be obtained by it. The paper is therefore divided into three parts, viz.:—(1) A description of the method itself, (2) critical experiments on the application of the method, and (3) some examples of its usefulness in field studies.

(1).—The Method.

Small tubes, about 4 cm. long and 0.9 cm. internal diameter, made of glass about 1 mm. thick, were sealed at one end and the edges carefully ground at the other. These were then half-filled with fresh granular calcium chloride, well pressed down and kept

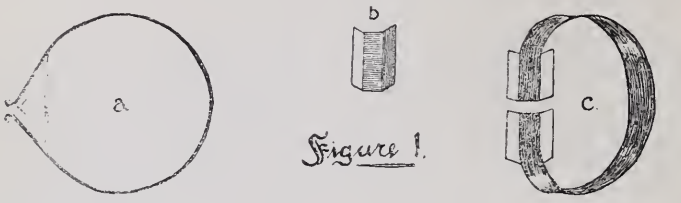


Figure 1.

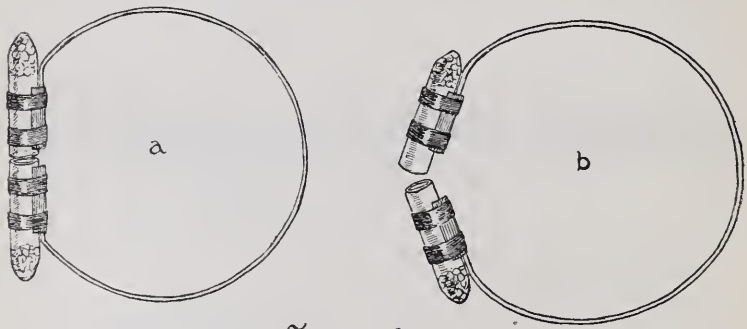
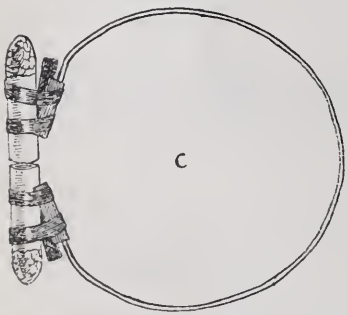


Figure 2.



Section II.—Figures 1 and 2, illustrating "A New Calcium Chloride Method of Measuring the Resistance to Water-Loss in Leaves."

(*For explanation see text.*)

in position by means of a loose plug of cotton-wool. These tubes were tightly corked and then weighed.

The problem of finding a suitable means of holding the tubes closely and firmly, and at the same time not too tightly pressed to the surface of the leaf, next received attention. Anything involving

the use of a screw or a clamp seemed liable to cause injury to the tissues of the leaf, and consequently it was thought desirable to devise something in the nature of a spring clip, which would be readily adjustable to thick or thin leaves. After several unsuccessful attempts, a modification of a steel trouser-clip was found to serve our purpose admirably. The ends of the clip were cut off and bent inwards (see Fig. 1, *a*), and a small piece of thin sheet-iron shaped as shown in the accompanying illustration (Fig. 1, *b*) was then soldered on to each straightened end in such a way as to form a groove into which a tube could very easily be fitted. A small piece of rubber was then glued to the surface of each groove, so that the tube when placed in position would lie firmly and not tend to slip up. The best method of attaching the tube to the clip was found to be by means of a small rubber-band, doubled round the tube and the end of the clip several times (Fig. 2, *a*).

The great advantage of this clip lies in its lightness, the average weight being about 14 gms. Most leaves can support this weight quite easily; in fact, in many cases as many as six clips can be attached to the same leaf. Any straining of the leaf can easily be avoided by providing a small support. Another advantage is the fact that it is very easily adjustable; for example, the pressure of the tubes on the surface of the leaf can quickly be varied. Where it is desirable, as in the case of soft, fleshy leaves, that the mouths of the tubes should press but lightly against one another, the tubes are fastened to the clip so that their open ends just protrude beyond the ends of the clip when in position for use. If, on the other hand, it is desired that the tubes should press very tightly against one another, as is often necessary when dealing with hard, sclerenchymatous and slippery leaves, the tubes are attached to the clip in such a way that their mouths protrude well beyond the ends of the clip. This causes a greater stretching of the clip, with the result that the tubes are more tightly pressed together. As the clip is made to carry two tubes, the open ends of which coincide with one another in the normal position, any undue extension of the clip causes the vertical axes of the two tubes to lie in different planes, with the result that the mouths do not coincide (Fig. 2, *b*). This is easily rectified by inserting a small wedge between the tube and the end of the clip (Fig. 2, *c*). By attaching the tube to the clip with a rubber-band instead of with thin wire, the insertion of the wedge is rendered a very speedy and easy process.

In cases where the rate of water-loss is measured from only one surface of the leaf, it is necessary to have something to press the leaf against the tube in use. The easiest and most effective method of doing this is by attaching an empty tube of the same bore as the one used to the other end of the clip.

The experimental procedure is extremely simple. Tightly corked, weighed tubes of calcium chloride are attached to the clips, and the corks removed just before fastening the clip to the leaf. At the end of a given period the clip is removed and the tubes immediately corked and weighed. To avoid the possibility of interchanging the corks, it is necessary to number each tube and the corresponding cork. For field studies the method has obvious advantages. A set

of numbered weighed tubes can be taken out and used at considerable distances from headquarters and then brought back to the laboratory and reweighed. An example of this will be given in a later section of the paper.

(2).—Critical Experiments on the Method.

Before any extensive use could be made of the method, it appeared necessary to investigate several possibilities which might impede its successful working or cause disturbing variations in the results obtained.

A.—Uniformity of Absorption over Long Periods.

The first difficulty suggested was that the power of calcium chloride to absorb water might steadily decrease with time, and that, where small quantities were used, this might become apparent within a somewhat short period. To test this, a small tube containing fresh calcium chloride was left open in the somewhat humid atmosphere of a greenhouse and weighed every two hours. The tube was placed in the greenhouse from 9 a.m. to 3 p.m. each day and was found to increase in weight at a uniform rate (0.005 gm. per 2 hours) for five days, the actual length of exposure being thirty hours. After this the rate gradually fell to 0.003 gm. per 2 hours. This showed clearly that even small quantities of calcium chloride retain their absorbing power over reasonably long periods.

As a further test, tubes which had been used on various leaves on several occasions were attached to the same leaf as tubes recently filled with fresh calcium chloride. Four tubes were used and were all attached to the lower surface of a single healthy leaf of *Uhdea* sp. (a tall shrub with large soft leaves) for a period of three hours in the morning and another of one and a half hours in the afternoon. The results obtained are shown in the accompanying table. Tubes I and II contained fresh calcium chloride, while III and IV contained some which had previously been used.

Table I.

No. of Tube.	Increase in Weight.	
	9.30 a.m.–12.30 p.m.	1 p.m.–2.30 p.m.
I	0·0180	0·0056
II	0·0176	0·0052
III	0·0188	0·0060
IV	0·0178	0·0054

It will be noticed that the difference between No. II and No. III, for instance, is very little greater than that between No. I and No. II.

During the same periods, two similar tubes, Nos. V and VI, containing approximately the same amounts of calcium chloride, were left exposed to the atmosphere in the vicinity of the plant. No. V contained fresh calcium chloride, whereas No. VI contained pre-

viously used chloride similar to that in Nos. III and IV. The increases in weight were as follows:—

TABLE II.

No. of Tube.	Morning.	Afternoon.
V	0·0074 gramme	0·0040 gramme
VI	0·0076 ,,	0·0046 ,,

From this it is clear that the calcium chloride in No. VI had lost none of its efficiency as an absorbent of water. During the first period of three hours, the two tubes were placed side by side on the ground. In the second period they were placed in convenient positions on a tree, No. V being more or less vertical and No. VI horizontal. This difference in position may account for the greater disparity in the afternoon results, as any air movements would probably have a greater effect upon the tube in the horizontal position.

These combined results show that calcium chloride may be used even in small quantities over a considerable length of time and yet retain its effectiveness as an absorbent of water. As to how long tubes may be used without recharging, it hardly seems possible to lay down any definite rule, as the rates of water loss vary so tremendously. It seems clear, however, that tubes can be used over fairly long periods without any very great error being introduced.

B.—The Amount of Calcium Chloride Used.

The possibility that the amount of water absorbed from a leaf might vary with the amount of calcium chloride present in the tube next presented itself. If this were the case, the method would be less easily applied, as it would necessitate having equal weights of calcium chloride in each tube. It was found, however, that within reasonable limits the amount of calcium chloride did not affect the amount of absorption. In numerous experiments tubes containing half or double the usual amount of the dehydrator were found to absorb similar amounts of water to those with the normal amount, when attached to the same leaf. The following table is a typical example of the results obtained. Tubes I, II, and III contained only half the amount of calcium chloride in tubes IV, V, and VI. All the tubes were attached to the under surface of a leaf of *Uhdea* sp. for periods of two hours.

TABLE III.

Amount of Calcium Chloride Used.	Period of Exposure.	10 a.m.–12 noon.		1 p.m.–3 p.m.	
	Tube No.	Increase.	Average.	Increase.	Average.
Half the usual amount.....	I	0·0056 gm.	0·0061 gm.	0·0060 gm.	0·0065 gm.
	II	0·0064 ,,		0·0072 ,,	
	III	0·0062 ,,		0·0064 ,,	
Usual amount..	IV	0·0064 gm.	0·0061 gm.	0·0058 gm.	0·0061 gm.
	V	0·0062 ,,		0·0064 ,,	
	VI	0·0058 ,,		0·0060 ,,	

Of course, carrying the variation to extremes, such as placing only a single small piece of calcium chloride in some tubes and completely filling others, may affect the results considerably, but this is not likely to occur in practice.

C.—The Position of the Calcium Chloride in the Tubes.

Another question which seemed worth looking into was whether the distance of the calcium chloride from the leaf-surface made any difference to the results obtained. In practice, if the tubes used are not of exactly the same length, the calcium chloride may be nearer the leaf-surface in some than in others. To test this, a set of six tubes were filled with the salt; three—Nos. I, II, and III—in the usual way with the calcium chloride at the bottom of the tube and kept in position with a loose plug of cotton-wool about half-way down the tube, and three—Nos. IV, V, and VI—with their lower portion plugged with cotton-wool and then filled with calcium chloride, so that the final loose plug of cotton-wool was near the top of the tube. The tubes were all attached to the under surface of the same leaf. The results obtained are shown in Table IV, and indicate that the slight changes of level of the calcium chloride, likely to occur in practice, will not have an appreciable effect upon the results obtained.

TABLE IV.

Position of Calcium Chloride in Tube.	Period of Exposure.	10.30 a.m.–2 p.m.		2.30 p.m.–4 p.m.	
	Tube No.	Increase.	Average.	Increase.	Average.
Half-way up the tube	I	0·0244 gm.	0·0243 gm.	0·0108 gm.	0·0108 gm.
	II	0·0250 ,,		0·0114 ,,	
	III	0·0234 ,,		0·0102 ,,	
Nearly to top of tube	IV	0·0252 gm.	0·0237 gm.	0·0106 gm.	0·0107 gm.
	V	0·0248 ,,		0·0104 ,,	
	VI	0·0210 ,,		0·0112 ,,	

D.—Variations in the Size of the Tubes Used.

As tubes of different sizes are likely to be required according to the size of the leaf to be investigated, it was necessary to compare the results obtained with such tubes when they are all used on the same leaf. Tubes of six different sizes, the internal diameters ranging from 0.5 cm. to 1.5 cm., were made, and two tubes of each size used. These were all attached to the under surfaces of leaves of *Phytolacca dioica* for two periods of four hours each. The results are tabulated below.

TABLE V.

Period of Exposure.		First day, 9 a.m.–1 p.m.			Second day, 9 a.m.–1 p.m.		
Tube No.	Interval Diam.	Increase in Weight.	Average.	Increase in Weight per sq. cm. cross section.	Increase in Weight.	Average.	Increase in Weight per sq. cm. cross section.
I	1·5 cm.	0·0692	0·0676	0·0382	0·0464	0·0453	0·0256
II		0·0660			0·0442		
III	1·0 cm.	0·0312	0·0321	0·0409	0·0176	0·0185	0·0264
IV		0·0330			0·0194		
V	0·94 cm.	0·0304	0·0300	0·0432	0·0142	0·0138	0·0199
VI		0·0296			0·0134		
VII	0·83 cm.	0·0216	0·0207	0·0383	0·0110	0·0112	0·0207
VIII		0·0198			0·0114		
IX	0·63 cm.	0·0120	0·0113	0·0362	0·0080	0·0080	0·0256
X		0·0106			0·0080		
XI	0·47 cm.	0·0068	0·0071	0·0409	0·0048	0·0045	0·0259
XII		0·0074			0·0042		

From these figures it is evident that even two tubes of the same bore may give results differing by as much as 10 per cent.; for example, Nos. III and IV in the second period above. Generally, however, the difference is about 5 per cent. or 6 per cent. These differences presumably represent the variation between different leaves and different parts of the same leaf. Consequently, it is essential in comparing different plants to take the average of a number of results for each one.

It is also evident that tubes of different bores are not strictly comparable since the results calculated for unit area of cross-section may differ by as much as 30 per cent. For all comparative work, therefore, it is necessary to use tubes of the same bore.

E.—Injury to the Leaf Surface.

In a few of the preliminary experiments it was found that occasionally exceptionally high increases in weight occurred. Examination of the leaf-surfaces in these cases showed that this was due to the tissues having been damaged by the pressure of the tubes. In one experiment the under-surfaces of certain leaves were deliberately injured and tubes placed over the damaged portion and compared with tubes over undamaged portions. The increase of weight in the former was found to be three to four times greater than that in the latter. Great care must therefore be taken in attaching the tubes to the leaf to see that the rims press evenly all round on the leaf-surface and do not cut it at all.

F.—Transpiration and Resistance to Water Loss.

In this method of measuring water-loss from leaves, as in all methods involving the use of calcium chloride, it should not be assumed that the increase in weight of the tubes represents the actual rate of transpiration at any given time. The particular part of the leaf covered by the tube is in reality subject to conditions which will cause it to transpire more rapidly than the surrounding portions of the leaf. The air within the tube, though perfectly still, is also perfectly dry, and consequently the evaporation from the leaf into the tube will be considerably increased. In view of these facts it seems clear that the method really measures the resistance of leaves to water-loss at any given time. In order to determine the relationship between this and the true rate of transpiration, the following experiment was performed.

A large leaf of *Uhdea* sp. with a long petiole was cut, and its area was then determined. The cut end of the petiole was then passed through a cork into a tube of water. Tube and leaf were then weighed, and weighed calcium chloride tubes of known size were attached to the upper and lower surfaces of the leaf. After a given period the calcium chloride tubes were removed and reweighed, and the loss of weight from the leaf as a whole was determined. knowing the cross-sectional area of the tubes and their increase in weight, it was possible to calculate the amount of water which would be given off by the whole leaf when exposed to calcium chloride and to compare it with the actual amount of water lost. Details of the experiments are given below.

A.—Leaf kept in the greenhouse:—

(i) Increase in weight of calcium chloride (average of 3 tubes) = 0.0053 gramme. Total area of leaf used = 137.6 sq. cm. Area of cross-section of calcium chloride tubes = 0.671 sq. cm.

Water lost from total leaf-surface (calculated from increase in weight of calcium chloride tubes) = 1.082 gramme.

Loss of weight of leaf during period that tubes remained attached = 0.5039 gramme.

$$\frac{\text{Actual loss of weight of leaf}}{\text{Loss calculated from tubes}} = \frac{0{\cdot}5039}{1{\cdot}082} = \frac{1}{2{\cdot}147}.$$

(ii) Increase in weight of calcium chloride (average of 3 tubes) = 0.0049 gramme. Total area of leaf used = 136.48 sq. cm. Area of cross-section of calcium chloride tubes = 0.671 sq. cm.

Water lost from total leaf-surface (calculated from increase in weight of calcium chloride tubes) = 1.028 gramme.

Loss of weight of leaf during period that tubes remained attached = 0.4060 gramme.

$$\frac{\text{Actual loss of weight of leaf}}{\text{Loss calculated from tubes}} = \frac{0{\cdot}4060}{1{\cdot}0280} = \frac{1}{2{\cdot}5}.$$

B.—Leaves kept in the open:—

(i) Increase in weight of calcium chloride (average of 3 tubes) = 0.0061 gramme. Total area of leaf used = 145.12 sq. cm. Area of cross-section of calcium chloride tubes = 0.671 sq. cm.

Water lost from total leaf-surface (calculated from increase in weight of calcium chloride tubes) = 1.326 gramme.

Loss of weight of leaf during period that tubes remained attached = 1.3312 gramme.

$$\frac{\text{Actual loss of weight of leaf}}{\text{Loss calculated from tubes}} = \frac{1{\cdot}3312}{1{\cdot}326} = \frac{1}{0{\cdot}996}.$$

(ii) Increase in weight of calcium chloride (average of 3 tubes) = 0.0060 gramme. Total area of leaf used = 144.32 sq. cm. Area of cross-section of calcium chloride tubes = 0.671 sq. cm.

Water lost from total leaf-surface (calculated from increase in weight of calcium chloride tubes) = 1.290 gramme.

Loss of weight of leaf during period that tubes remained attached = 1.3414 gramme.

$$\frac{\text{Actual loss of weight of leaf}}{\text{Loss calculated from tubes}} = \frac{1{\cdot}341}{1{\cdot}290} = \frac{1}{0{\cdot}96}.$$

The difference between these two sets of experiments is very striking and shows clearly that what is measured is really "resistance to water-loss" and not transpiration. This is evidently only slightly affected by external conditions, unless, of course, these cause movements of the stomata. Thus, in the first experiment above, the low rate of transpiration of the leaf is not due to increased resistance to water-loss, but simply to the fact that the external conditions are such as to lower the rate of evaporation. Consequently, in this case there

is a fairly large difference between the results obtained by the loss of weight method and by the calcium chloride method. In the open, on the other hand, where external conditions are tending to cause a high rate of evaporation, the results obtained by the two methods show a rather close agreement.

(3).—Some Applications of the Method.

A.—Comparison of the Two Surfaces of a Leaf.

The method obviously affords a very easy means of comparing the rate of loss from the upper and lower surfaces of a leaf, and as a large number of clips can be obtained quite cheaply, it is very useful for class work. A typical example of the results obtained, for instance, with a leaf of *Phytolacca dioica*, is as follows:—

Lower Surface.			Upper Surface.		
Tube No.	Increase in weight.		Tube No.	Increase in weight.	
IV	0·0010	0·0011 gramme.	XXVI	0.0056	0.0059 gramme.
V	0·0012		XXVII	0·0060	
VI	0·0010		XXVIII	0·0062	

The upper surface is therefore more than five times as resistant to water-loss as the lower, and it is easy to show that this is due to the unequal distribution of the stomata on the two surfaces.

B.—Comparison of Leaves in Sunlight and in Shade.

Tubes were attached to similar and equal sized leaves of *Phytolacca dioica*, some of the leaves being in full sunlight and some in complete shade. In one experiment (typical of several) the results obtained were:—

Average increase in weight of tubes attached to leaves in bright sunlight, 0.0147±0.0003.

Average increase in weight of tubes attached to leaves in shade, 0.0072±0.0006.

The greater loss from leaves in full sunlight probably indicates that their stomata are more widely open than are those of the shaded leaves.

C.—Comparison of Young and Old Leaves.

For this experiment three tubes were attached to the lower surfaces of old leaves and three to the lower surfaces of very young leaves of *Ricinus communis* for two hours. That the young leaves gave off far more water, that is, were less resistant to water-loss, than the old leaves is clearly seen from the following figures:—

Increase in weight of tubes on young leaves, 0.0118 ± 0.0006 gramme.

Increase in weight of tubes on old leaves, 0.0073 ± 0.0004 gramme.

D.—Comparison of the Resistance to Water-Loss of Different Plants.

The method was used to compare the resistance to water-loss of *Ptaeroxylon utile*, *Portulacaria afra*, and *Heteromorpha arborescens*, three common indigenous shrubs growing within a few yards of the college buildings. The results are tabulated in Table VI.

Table VI.

Time.	*Ptaeroxylon utile.*	*Heteromorpha arborescens.*	*Portulacaria afra.*
7 a.m.– 9 a.m.	0·0034 ± 0·0004	0·0037 ± 0·0003	0·0022 ± 0·0004
9 a.m.–11 a.m.	0·0065 ± 0·0003	0·0075 ± 0·0007	0·0039 ± 0·0007
11 a.m.– 1 p.m.	0·0055 ± 0·0003	0·0072 ± 0·0004	0·0028 ± 0·0004
1 p.m.– 3 p.m.	0·0057 ± 0·0005	0·0087 ± 0·0003	0·0028 ± 0·0004
3 p.m.– 5 p.m.	0·0048	0·0063 ± 0·0005	0·0021 ± 0·0003

In each period the average increase in weight of three tubes is given.

It is at once evident that resistance to water-loss is greatest in the succulent *Portulacaria afra*, which shows the smallest loss of water, and least in the thin-leaved *Heteromorpha arborescens*, which shows the greatest loss of water.

One other point is worth noting. Both *Ptaeroxylon* and *Portulacaria* show the greatest loss between 9 a.m. and 11 a.m., whereas *Heteromorpha* does not reach a maximum until between 1 p.m. and 3 p.m. Possibly this is due to differences in stomatal behaviour, but this possibility was not investigated at the time.

E.—Use in Field Studies.

At the time that the present investigation was proceeding, some preliminary studies were being made of the effect of slope exposure upon climate and vegetation (1). A comparison of the differences in climatic factors on the northern and southern slopes of a hill near Maritzburg in the course of a single day in winter was carried out, and at the same time it was desired to obtain information as to the rates of water-loss from trees of the same species—*Cussonia spicata*—growing on the two slopes. Weighed, numbered tubes were taken out to the hillside, and three tubes were attached to a tree on each slope for two-hour periods throughout the day. They were then returned to the laboratory and weighed the following day. The results are tabulated below.

Table VII.

Time.	South slope.	North slope.
7.45 a.m.–9.45 a.m.	0·0091 ± 0·0006	0·0075 ± 0·0010
9.45 a.m.–11.45 a.m.	0·0139 ± 0·0006	0·0110 ± 0·0004
11.45 a.m.–1.45 p.m.	0·0170 ± 0·0009	0·0119 ± 0·0005
1.45 p.m.–3.45 p.m.	0·0107 ± 0·0007	0·0085 ± 0·0011
3.45 p.m.–5.25 p.m.	0·0054 ± 0·0004	0·0062 ± 0·0004

Concurrent measurements of various climatic and edaphic factors, such as sunlight intensity, evaporation rates, air temperature, soil temperature and soil moisture, showed that conditions on the northern slope were much drier and more favourable to a high rate of transpiration. Consequently, it was interesting to find that, except for the early morning and the late afternoon, the rate of loss of water was lower from the tree on the northern slope than from that on the southern. This suggests that when grown under unfavourable conditions as regards water, a species becomes more resistant to water loss; for example, it may open its stomata less widely than when grown under favourable conditions.

Summary and Conclusions.

1. A new calcium chloride method of measuring water-loss from leaves, depending on the use of small tubes attached directly to the leaf-surface instead of being placed under bell-jars, is described.

2. A special clip for holding the tubes in position has been devised and is fully described.

3. Critical experiments on the method indicate that—

(*a*) calcium chloride retains its efficiency as an absorber of water over reasonably long periods even when used in small quantities only;

(*b*) the results obtained are not affected by variations in the amount of calcium chloride in the tubes (within reasonable limits) nor in the proximity of the chloride to the leaf surface.

4. The results obtained vary irregularly with variations in the bore of the tubes, and for comparative work it is necessary always to use tubes of the same bore.

5. Great care must be taken not to injure the leaf-surface. Injury is likely to occur if the tubes on the clip are not properly adjusted before being attached to the leaf.

6. The method is believed to measure not the actual transpiration of a leaf, but its power of resisting water-loss.

7. Examples of the application of the method are given.

8. Leaves in bright sunlight are less resistant to water-loss than leaves in shade; consequently, in comparing different plants care must be taken that the tubes are either all in the sun or all in the shade.

9. Young and old leaves also differ in their resistance to water-loss; hence tubes must always be attached to leaves of similar age and size and in a similar position on the plant.

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SECTION III.

The Measurement of Light Intensity in South Africa, with Special Reference to Plant Habitats.

Introduction.

The importance of light intensity as a factor influencing physiological processes in plants, as well as their distribution and successional relationships has long been appreciated by botanists. The usual method of photochemical measurement is by means of standard

silver chloride paper, as first suggested by Bunsen and Roscoe (1858). The method is simple and satisfactory up to a point, especially if only a comparison of "shade intensities" is required. Photographic actinometers are in everyday use, and by their help it is possible to determine sufficiently accurately in a few minutes what percentage of full sunlight penetrates into any shady habitat. Observations of this nature, in connection with the vegetation of Natal were published by one of us in 1912.*

It was, however, felt that for comparison of full sunlight intensities, as well as for comparison of certain slight degrees of shade, one of the slower, more accurate chemical methods should be tried. The most promising seemed to be that originally described independently by Dr. Albert R. Leeds, of Philadelphia, and by Dr. Angus Smith (1880). It was extensively used by Dr. Bailey and his colleagues in Manchester, and an interesting paper, giving results obtained by this method in England, India, and elsewhere, was published by Dr. G. J. Fowler (1907-8).† It has not apparently been used much, if at all, by plant ecologists, and therefore, a brief description of the method may be given.

Description of the Method of Measurement.

The following solutions are required:—

(*a*) Potassium iodide (KI), 20 grammes per litre.
(*b*) Sulphuric acid (H_2SO_4), 11.85 grammes per litre.
(*c*) Sodium thiosulphate ($Na_2S_2O_3$), 1.982 gramme per litre.
(*d*) Centinormal iodine (I), 1.27 gramme dissolved in KI and made up to 1 litre.

Ten c.c. of (*a*) and 10 c.c. of (*b*) are placed in a glass bottle (with accurately ground-glass stopper) and exposed on a square of white porcelain to sunlight for a known time. The result is then calculated as milligrams of iodine liberated per 100 c.c. of solution (*a*) in one hour [12.77 c.c. of (*c*) should decolorize 10 c.c. of (*d*), i.e. 1 c.c. of (*c*) = 1 milligram of iodine].

Before and after exposure, the bottles containing mixtures of (*a*) and (*b*) are kept in a thick black cloth bag and kept in the dark until titrated. In all experiments one bottle (unexposed) was kept as a control.

In titration, starch paste is used as indicator, and hence we have a clear, definite, and readily determined end-point.

Critical Experiments on the Method.

1. *Effect of Temperature.*—It was stated by previous users of the method that ordinary temperature variations have practically no effect. To test this statement the ordinary mixture was heated up to 60° C., and that temperature was maintained for about fifteen minutes. On testing with starch paste, the colour effect was practically unappreciable. Dr. Fowler kept the mixture in an incubator for twelve hours at a temperature of 97° F. with the same result.

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* "The Vegetation of Natal." By J. W. Bews. *Ann. Natal Museum*, II. 1912.
While this memoir was in the printer's hands, two papers on light measurements have appeared. See K. W. Baird and also R. H. McCrea in *Journal of Ecology*, XI, 1, May, 1923.

† "Some Observations on the Chemical Action of Tropical Sunlight." By G. J. Fowler. *Memoirs and Proceedings of the Manchester Literary and Philosophical Society*, LII, 1907–08.

2. *Consistency of Results.*—Separate bottles exposed together for the same length of time gave identical results.

3. *Duration of Exposure.*—The effect of variations in the duration of exposure might be expected to be considerable, and the following experiments were performed as a test:—

Table I.

Time.	Duration.	Cubic Centimetres Thio.	Mgms. Iodine per 100 c.c. KI per hour.	Remarks.
March 8th, 1922.				
10–12	2 hours	3·7	18·5	Full sunlight.
11–1	2 ,,	4·1	20·5	,,
12–2	2 ,,	3·6	18·0	,,
11.5–12.5	1 hour	2·7	27·0	,,
12.1– 1.1	1 ,,	2·9	29·0	,,
1.10–2.10	1 ,,	2·6	26·0	,,

The difference in amount of iodine liberated for the longer and shorter exposures is thus shown to be so great that where strict comparisons are to be made, the same length of exposure must be given. In the actual experiment an exposure of one hour was given. This discrepancy is due, no doubt, as Fowler supposes, largely to the effect of the liberated iodine in absorbing the chemically active rays. Fowler's experiment was repeated by exposing two bottles simultaneously: one in the usual manner, the other immersed in a centinormal solution of iodine. Under these extreme conditions, the solution exposed in the usual way showed no less than eleven times the photo-chemical effect of the one immersed in iodine solution. It may be suggested, however, that in addition to absorption of light by liberated iodine, there is also the reversibility of the reaction:—

$$2\,HI \rightleftarrows H_2O + I_2.$$

4. *The Effect of Dilution.*—Two mixtures—the one diluted with its own volume of distilled water, the other normal—were exposed for one hour simultaneously, giving the following results:—

Diluted mixture, 17 milligrams iodine per 100 c.c. KI.
Undiluted mixture, 24 milligrams iodine per 100 c.c. KI.

At the start, action is slower in the diluted mixture, as we should naturally expect in accordance with the law of mass action. Finally, however, in the undiluted mixture, the liberated iodine shows more of the effect already described retarding the action. The longer the period of exposure the more nearly the results tend to agree.

Comparison of General Results with those Obtained Elsewhere.

Before discussing the application of the method to plant ecology, it is interesting to compare some of the results obtained in full sunlight at approximately the same hour of the day in South Africa and those given by Dr. Fowler (partly quoted from Dr. Bailey). The time of the year is noted as being, of course, important.

TABLE II.

Date.	Time.	Duration.	Place.	Mgms. Iodine per 100 c.c. KI per hour.
19th March, 1906	11–12	1 hour	Calcutta	30·0
22nd March, 1906	11–12	1 ,,	,,	28·0
30th March, 1906	12–1	1 ,,	,,	26·0
2nd April, 1906	12.10–1.10	1 ,,	,,	29·0
2nd May, 1906	11.30–1	1½ hour	Agra	30·0
8th May, 1906	12.26–12·56	½ hour	Arabian Sea	42·0
11th May, 1906	12–12.30	½ ,,	Red Sea	34·0
1st January, 1892	11–1	2 hours	Manchester	3·0
10th January, 1892	11–1	2 ,,	,,	1·0
31st January, 1892	11–1	2 ,,	,,	3·75
1st May, 1892	11–1	2 ,,	,,	12·0
9th June, 1892	11–1	2 ,,	,,	12·0
18th August, 1892	12–1	1 hour	Pontressina, 6,000 ft.	26·5
29th August, 1892	12–1	1 ,,	,, 10,000 ft.	30·2
17th April, 1922	12–1	1 ,,	Durban	21·0
17th April, 1922	12–1	1 ,,	Johannesburg	34·0
23rd May, 1922	12–1	1 ,,	Pietermaritzburg	25·0

The highest result given by Dr. Fowler was for the Arabian Sea, but as this was the result of an half-hour exposure, it is not strictly comparable with the one-hour observations.

The table shows that South Africa has light intensities comparable with those of India, although, on the whole, slightly less. In England, on the other hand, the highest summer record is 14.0, or about half the average April record of South Africa. With the exception of a few observations (see Table V), we have at present no record of South African midsummer intensities. The lowest winter record for Manchester is only 1 in the bright sunshine. Considering how much of the time in winter the sky is overcast in England, it is probably not too much to say that in one day in South Africa there is as much actinic sunlight as in about a month of Manchester's winter weather.

Clearer comparisons will be possible when further observations throughout the year have been taken in South Africa. There are many important physiological effects of light on human beings as well as on plants. In view of our results as compared with those of India, it is rather difficult to explain our comparative immunity from sunstroke. It would appear that sunstroke can hardly be a photochemical effect.

THE EFFECT OF ALTITUDE.

Increase of light intensity with increased altitude is a generally accepted fact, and various physiological and morphological variations in plant species have been ascribed to the direct effect of increased light (*cf.* the colour change in such forms as *Dierama pendula*, *Helichrysum adenocarpum*, *Moraea* spp., etc., with increased altitude). One of the first applications of this method of measuring was naturally to a comparison of full sunlight intensities at various stations of different altitudes. Advantage was taken of the fact that during the Easter vacation many of the students of Botany at this centre went back to their homes. It was arranged that mixtures should be exposed at the same hour (viz., 12-1) on a fixed day, providing the sky was cloudless. They were brought back to the laboratory to be titrated. Other experiments were carried out on the Zwaartkop mountain and at Maritzburg. The results are given in Table III.

Table III.

Date.	Time.	Duration.	Place.	Altitude.	Mgms. Iodine per 100 c.c. K I per hour.
24th March, 1922..	12.20–1.20	1 hour..	Zwartkop Mt.....	4,750 ft.	30·5
24th March, 1922..	12.7–1.7	1 ,, ..	Pietermaritzburg..	2,230 ft.	26·0
17th April, 1922...	12 1	1 ,, ..	Durban.....	Sea-level	21·0
,, ...	,,	1 ,, ..	Pietermaritzburg.	2,230 ft.	25·0
,, ...	,,	1 ,, ..	Ladysmith.....	3,284 ft.	30·5
,, ...	,,	1 ,, ..	Johannesburg....	5,470 ft.	34·0

These figures give the expected result and indicate quite distinctly the marked effect of increased altitude. The result for Johannesburg is, of course, only a single reading, and it may be exceptional, but it is noteworthy as being equal to that given by Fowler for the Red Sea.

The Influence of Aspect, Slope, and Exposure.

While the vegetation of a country such as Natal, which rises steeply from sea-level to an altitude of 11,000 feet, shows in a general way the effect of altitude and can be divided into main vegetation regions accordingly, the effect of the highly broken topography is seen more clearly in the vegetation of any small area. Whether it is a hill or valley that is being considered, one side may be expected to receive a greater total amount of light during the day and throughout the year. Since in the southern hemisphere the sun passes round the northern half of the sky, slopes which face the north obtain more total insolation than slopes facing the south. Steepness of the slope must also be taken into account.

The difference in the vegetation of the two slopes in most of the main river valleys of Natal is extreme. Thus, it is usual to find that the valley slope which faces north (i.e. the slope on the southern bank of the river, as in Natal, all rivers flow in an easterly direction), has a dense xerophytic type of succulent and thorny scrub as its climax vegetation, dominated by euphorbias, aloes, etc. The opposite slope facing south is usually open and grassy, and in places shows succession to mesophytic forest. The same thing applies to the hills which intervene between the river valleys.

Knowing the angle of slope and the altitude of the sun at any particular time of the day, it is possible to calculate mathematically the comparative total amounts of insolation. To do this, however, for a whole day and still more for a whole season would be a laborious task. The problem is further complicated by differences in other climatic factors, e.g. relative humidity of the atmosphere, amount of dust, etc.

Observations were made on Signal Hill, near Maritzburg, throughout the day on (1) the north side with a moderately steep gradient (30° with horizontal) and (2) on the south side with a much steeper slope (45°). The results are given in Table IV in milligrams of iodine per 100 c.c. KI in one hour, as before.

TABLE IV.

Time.	North Slope.	Time.	South Slope.	
25th May, 1922.				
7.35– 8.35 a.m.	3·5	8– 9 a.m.	4·0	Winter.
8.35– 9.35 ,,	9·5	9–10 ,,	11·5	
9.35–10.35 ,,	13·5	10–11 ,,	14·5	
10.35–11.35 ,,	20·5	11 a.m. 12 noon	20·5	
11.35 a.m.–12.35 p.m.	25·5	12– 1 p.m.	22·5	
12.40 p.m.– 1.40 ,,	24·5	1– 2 ,,	18·5	
1.40–2.40 p.m.	21·5	2– 3 ,,	7·5	
2.40–3.40 ,,	17·5	3– 4 ,,	5·0	
3.40–4.40 ,,	9·5	4– 5 ,,	3·0	
4.40–5.40 ,, (dark)	1·0	5–5.35 ,,	·3	
TOTAL... ..	146·5	TOTAL.. ..	104·3	

The observations on the south side were made half an hour later than on the north side, which explains why the first few readings were slightly greater. The marked difference in the two sides is clearly shown in the afternoon. Making allowance for the half-hour lost in the early morning, the total amounts may be taken as about 147 for the north side as against about 107 for the south side in midwinter.

On the same day, 25th May, co-operative experiments on (1) soil and air temperatures, (2) rate of evaporation from an atmometer, (3) rate of transpiration from *Cussonia spicata* by the calcium chloride tube method described in section II were carried out.*

The measurement of the total insolation for both sides of Signal Hill was again performed on the 5th December, the results in milligrams of iodine per 100 c.c. KI per hour being given in Table V.

TABLE V.

Time.	North Slope.	South Slope.	
8–9 a.m.	22	20·8	Summer.
9–10 ,,	23	22·1	
10–11 ,,	25·5	24·5	
11–12 ,,	29·5	28·5	
12– 1 p.m.	31·2	30·5	
1– 2 ,,	30·8	30·0	
2– 3 ,,	27·2	26·5	
3– 4 ,,	22·0	19·0	
4– 5 ,,	15·0	11·0	
5– 6 ,,	9·0	6·0	
TOTAL.....	235·2	218·2	

The difference between the total amounts of insolation is not perhaps as great as would be expected, but it must be remembered exposures commenced only at 8 a.m., when the sun is well risen. After 6 p.m. no further readings were taken, as the sudden cloudiness in the last hour rendered them useless, even though at this time of the year the sun sets considerably later than this.

Further, there is only a slight difference between the two sides for any period, specially at or towards midday. This is only natural when one considers that the sun in summer rises due east and is practically directly overhead at midday. The afternoon periods

* "The Effect of Slope Exposure upon the Climate and Vegetation of a Hill near Maritzburg." By R. D. Aitken. *South African Journal of Science*, XIX, 1922, p. 207.

show an appreciable difference. It is to be regretted that it was impossible to make a 6-7 p.m. exposure which would have made the difference more pronounced.

In the graph submitted there are several points made clear:—

(1) Summer insolation is considerably higher than that of winter. The summer readings are perhaps nearly as high as possible since they were taken after three days of very heavy rain (clearing effect on atmosphere). Further, there was hardly a cloud in the sky.

(2) For any given period during the day, the insolation on both sides tends to be more nearly equal in summer than in winter (explained above).

(3) In the winter reading for the south slope, the sudden drop in the curve (2-3 p.m.) is due to the fact that the south slope passes into complete shade about 2.30 p.m. In summer, this only takes place about 5.30 p.m.

(4) The irregularity in the curves for winter is due to irregularities in the clouding of the atmosphere.

The Effect of Water-Surface.

Experiments in this connection would seem to show that water-surface increases insolation possibly on account of reflection. At Albert Falls, bottles were exposed simultaneously—one on a rock just above the surface of the water, while the other was placed about 100 yards from the water. The results were:—

Table VI.

Date.	Time.	Mgms. of Iodine per 100 c.c. KI per hour.	Situation.
19th April, 1922.....	12.35–1.35	29 full sunlight	On rock above water.
19th April, 1922.....	12.35–1.35	26 ,,	On the bank.

This, however, is a single reading and should be confirmed.

The Effect of Rain.

Experiments in this connection show that rain has a clarifying effect, removing dust particles, etc., from the atmosphere, and thus tends to increase insolation. On the 17th March, after a very heavy storm (cloud-burst) on the 16th, the reading, as early as 9-10 a.m., was found to be as much as 22.5, whereas the average midday reading for this time of the year is only 25 milligrams iodine per 100 c.c. KI per hour. The results for Signal Hill (Table V), as already mentioned, illustrate the same point.

The sudden stimulation to growth in plants after rain is usually considered due to the increased moisture-content in the soil. Increased light intensity is also probably an important factor.

Application of the Method to Analysis of Plant Communities and to Plant Succession.

Plants have been divided roughly, according to their light requirements, into (1) sun-loving (heliophils), and (2) shade-loving (sciophils). Numerous observations in the Town Bush Valley and Zwaartkop were carried out with a view to determining, if possible,

the maximum amount of light which can be endured by such obligate (or almost obligate) sciophils as *Streptocarpus* spp. Owing to the difficulty of eliminating other factors likely to prejudice the growth and distribution, no definite statement can be made, but a few of the results given below in Table VII will prove interesting, and further, will establish the advantage of a slow accurate chemical method when small intensities are to be measured.

TABLE VII.

One-hour Exposures.

Date.	Time.	Mgms. of Iodine per 100 c.c. KI per hour.	Locality.	Situation.
5th Dec., 1922..	2.45–3.45	5·0	Zwaartkop.....	In shade.
5th Dec., 1922..	2.50–3.50	5·5	Zwaartkop.....	In shade.
5th Dec., 1922..	2.55–3.55	4·9	Zwaartkop.....	In shade.
5th Dec., 1922..	1.30–2.30	33·0	Zwaartkop (at the summit)	In full sunlight.
5th Dec., 1922..	1.45–2.45	7·6	Zwaartkop.....	In shade.
4th Dec., 1922..	12. 5–1. 5	28·4	Town Bush.....	In full sunlight.
4th Dec., 1922..	12. 1–1. 1	7·9	Town Bush.....	In shade.
4th Dec., 1922..	12. 0–1. 0	6·1	Town Bush.....	In shade.

The main stages of succession in the chief plant formations of Natal have already been determined. There is room, however, for a vast amount of work in determining the conditions necessary to initiate each stage of the succession. The strict pioneer plants which colonize open situations require or are able to endure full amounts of light as determined in the tables already given. From the successional standpoint, the first important thing is to discover by how much in general the light intensity is reduced when a second stage is initiated.

In the great Grassland Succession *Aristida* associes constitute the first stage over great areas. *Themeda* associes usually succeed. The following observations show what amount of shade can be obtained in Aristida grassland. One bottle was exposed on top of an ant-heap in full sunlight; the other was placed in among the grass on the ground.

TABLE VIII.

Time.	Duration.	Mgms. of Iodine per 100 c.c. KI per hour.	Situation.
16th March, 1922			
9.40–10.40.....	1 hour.....	24	In full sunlight.
9.45–10.45.....	1 hour.....	6	Among Aristida grass.
10.45–11.15.....	½ hour.....	28	In full sunlight.
10.50–11.20.....	½ hour.....	8	Among Aristida grass.

Thus the Aristida associes is shown to reduce the amount of light to from 0.25 to 0.29 of the normal. The method gives greater precision than the actinometer readings by the darkening of sensitive paper.

It is important to note that the light intensity is thus considerably reduced, probably in most cases to at least one-third of the normal, before the more delicate seedlings of *Themeda* and other

hepophytic species can become established. Nevertheless, *Themeda* and most similar types appear to be sensitive only at the beginning of their germination. Later they endure and even demand full sunlight.

Light Intensities in the Forest.

These are exceedingly variable, and practically all degrees of shade can be obtained near the ground inside the forest. The trees themselves vary greatly in the amount of shade or conversely of light which they can tolerate.

They agree in being more shade-loving in their early stages than later. The method is particularly useful as showing the influence of varying light intensities on the different layer societies in undergrowth. Thus in the Town Bush near Maritzburg, the following observations were made:—

Table IX.

Date.	Time.	Duration.	Mgms. of Iodine per 100 c.c. KI per hour.	Situation.
17th April, 1922	1.10–1.50	40 minutes	6.0	Inside bush (average condition).
17th April, 1922	1 –2.10	70 minutes	4·7	*Plectranthus cooperi.*
17th April, 1922	12.55–1.55	1 hour	7·0	*Plectranthus coloratus.*
17th April, 1922	2.10–2.40	1 hour	2·0	Mosses and ferns only.
17th April, 1922	1 –2	1 hour	26·0	Outside bush in full light.
4th Dec., 1922	1.45–2.45	1 hour	7·9	*Dracaena.*
4th Dec., 1922	12 –1	1 hour	6·1	*Streptocarpus.*
4th Dec., 1922	12.5 –1.5	1 hour	28·4	Outside bush (cloudy at intervals).

This method of light measurement is useful also from the forest economy standpoint, as showing what degrees of light are necessary for proper regeneration of forest trees on the floor of the forest. The following observations illustrate this point:—

Table X.

Date.	Time.	Duration.	Mgms. of Iodine per 100 c.c. KI per hour.	Situation.
Stella Bush:				
18th April, 1922	11.57–12.57	1 hour	21·0	Full sunlight.
18th April, 1922	12 – 1	1 hour	11·0	Seedlings present.
18th April, 1922	11.50–12.50	1 hour	3·0	No seedlings (moss, ferns).
Zwaartkop:				
5th Dec., 1922..	1.30– 2.30	1 hour	33·0	Full sunlight.
5th Dec., 1922..	1.40– 2.40	1 hour	7·5	Seedlings present.
5th Dec., 1922..	1.45– 2.45	1 hour	1·0	No seedlings (moss and *Selaginella*).

Shade Effects of Various Common Forest Trees and of Chief Pioneer Species.

In connection with questions of light intensities in problems of forestry and of plant succession, various observations were made with a view to determining the amount of shade given by our more common forest trees and by our chief pioneer species. The results are given below in milligrams of iodine liberated per 100 c.c. of KI per hour as usual. It is important to note the intensity of full sunlight for the same period.

Two bottles were exposed—one in full sunlight and the other placed within two yards of the same tree-trunk in the shadiest spot on the side of the tree nearest the margin of the forest. This precaution was taken in order to eliminate the shade effect of neighbouring trees.

TABLE XI.

Forest Species.

Tree.	Date.	Time.	Situation.	Mgms. Iodine per 100 c.c. KI per hour.	Light Fraction.
Ficus.....	1st Dec., 1922	12·10– 1·10	Signal Hill (solitary tree	6·9	0·221
	1st Dec., 1922	12 –1	Signal Hill (full sunlight)	31·2	—
	18th Apr., 1922	11·50–12·50	Stella Bush (heart of bush)	3·0	0·143
	18th Apr., 1922	11·51–12·51	Stella Bush (full light)	21·	—
Podocarpus...	5th Dec., 1922	1·40– 2·40	Zwaartkop (margin)....	7·5	0·227
	5th Dec., 1922	1·30– 2·30	Zwaartkop (full sunlight)	33·0	—
Combretum...	4th Dec., 1922	11·50–12·50	Town Bush (margin)...	7·1	0·25
	4th Dec., 1922	12·5 – 1·5	Town Bush (full light)	28·4	—

These results are single readings, but they would seem to show that the particular trees in question have approximately the same shade effects. It is significant, however, that under these trees (not the *Ficus* in Stella Bush) we find the same type of herbaceous undergrowth predominantly grassy.

We shall now consider certain mountain pioneers, *Protea roupelliae*, *Panax gerrardi*, *Greyia sutherlandi*, and *Cussonia spicata*.

TABLE XII.

Pioneer Species.	Time.	Mgms. Iodine per 100 c.c. KI per hour.
Protea roupelliae.....	11·28–12·28	10·5
Greyia sutherlandi.....	11·25–12·25	11·0
Panax gerrardi.....	11·28–12·28	9·5
Cussonia spicata.....	10·55–11·55	12·0
In full sunshine.....	11·25–12·25	29·5

The leaves of these pioneer species vary considerably in texture. *Panax* has a very thin leaf, *Protea* a hard, thick leaf, while *Greyia* leaves occupy an intermediate position. The differences in shade intensity are, however, not very great. The following experiments show that leaf texture is relatively unimportant as compared with the total effect of the leaf canopy as a whole:—

(1) The usual mixture was placed in a glass bottle and the sides and bottom of the vessel darkened with glazed paper (black). Over the top of these, various single leaves of different plants (*Berkheya platyptera*, Arum Lily, Scilla, Begonia, Common Bean) were placed, so that any light rays passing into the solution in the bottle must of necessity pass through the leaf. The bottles were then exposed for different periods of 1-3 hours. The amount of liberated iodine after that time was unappreciable (in one case one drop of thio was sufficient to discharge entirely the very faintly blue colour).

This experiment was repeated in a dark room, the bottles containing the usual mixture being prepared as before. They were subjected to the rays of 500 candle-power light placed about twelve

inches away. The result was the same as before. It would appear, therefore, that leaves are efficient light absorbers, which we should expect from the part played by chlorophyll in photosynthesis.

(2) Chlorophyll was extracted from dried leaf-powder with 80 per cent. acetone in a suction filter, and the weak solution was placed in a small glass beaker. Into this was placed a glass bottle containing the usual mixture in such a way that a layer of the chlorophyll solution about 1 mm. thick (approximately the thickness of average leaf) covered the bottle. While a control bottle exposed to full sunlight for one hour showed that about 26 milligrams of iodine had been liberated, the screened bottle showed only the merest trace after two hours.

In view of the foregoing experiments, it is probable that the amount of shade produced by any tree is dependent not on thickness of the leaf, but primarily on the arrangement of the leaves. Since in Experiment No. 2 the chlorophyll solution is very weak, and therefore most leaves may be presumed to contain more chlorophyll than the solution, it is possible that the amount of chlorophyll and other pigments in the leaf may have a certain secondary effect. Size of leaf, too, with greater area shaded and greater possibility of overlapping, thus making a continuous screen, may be regarded as important. The leaf arrangement in both *Protea* and *Greyia* are very similar. The branches are leafless almost throughout their entire length, but towards their extremities fork into numerous smaller branches which bear terminal clusters of leaves.

In considering *Cussonia spicata* in the present connection, we should expect to find less shade, especially in view of the growth form. Experiment bears this out. A bottle exposed under *Cussonia* on Signal Hill, 10.55-11.55, showed that iodine liberated was 12 milligrams, while in the full sunlight, 11-12, the result was 29.5 milligrams. It is not surprising, then, that in the characteristic *Cussonia* "clumps," the plants found are practically heliophils, e.g. *Plectronia spinosa*, *Celastrus* (*Gymnosporia*), *Zizyphus mucronata*, which usually grow on or near the margins of our forests.

Application of the Method to Physiological Problems.

In considering the various individual plants and separate physiological processes, this method has a wide range of usefulness. Measurements of such processes, e.g. carbon assimilation, are of necessity spread over a fairly long interval of time. It is, then, particularly useful to have a summation method of recording the total insolation during such intervals. The same applies to transpiration and growth experiments where light is important. In a word, the method should prove useful as part of the ordinary laboratory practice.

Summary and Conclusions.

1. A method of measuring light intensities by means of liberating iodine from the potassium iodide in the presence of sulphuric acid and titrating with sodium thiosulphate has been applied to South African conditions.

2. Comparisons are given with results obtained in other countries by the same method by other writers.

3. The effects of altitude, slope, and exposure are illustrated.

4. The method has also been applied to the analysis of certain plant communities and to plant succession in Natal.

5. The method has been found useful as part of the ordinary laboratory practice in connection with physiological experiments.

SECTION IV.

Some Experiments on the Rate of Water-Loss during the Drying of Leaves.

Introduction.

That the leaves of different plants lose water at very different rates, even under practically identical external conditions, is one of the most easily demonstrated of plant physiological facts, and it is an obvious deduction that this is to be attributed to differences in the structure of the leaves. A large number of structural features which may have the effect of accelerating or retarding water-loss have gradually come to light, and are, for the most part, very familiar to botanical students. Thus it is clear that the size, number, and distribution of the stomata, the character of the cuticle, the size of the intercellular spaces, the presence or absence of a hairy covering are all factors which will have a considerable effect on the rate of water-loss. The amount of sclerenchymatous tissue present in a leaf might also be regarded as a factor of some importance, and an indication of this was obtained during the investigation described in Section I of this memoir. That certain types of leaves could not be injected by the method then used appeared to be due to the fact that in these leaves the lamina was partitioned off into very small "islands" of soft tissue by means of very fine veins. The effectiveness of these barriers in preventing the entrance of the injection fluid to these "islands" suggested that they might also serve, though in a different way, to prevent the loss of water. Under conditions resulting in lowering the water-content, the water present in these islands may be expected to pass into a condition of very high tension, the surrounding sclerenchyma providing girders to which the water would very strongly cohere. The work of Dixon (1) on the ascent of sap has amply demonstrated the possibility of such high tensions being set up. The smaller the size of the islands, the greater will be the force with which the water will be held, and hence the lower the rate of water-loss. The present investigation aimed at determining the differences in the rate of water-loss from different leaves, particularly from those showing pronounced differences in the distribution of their sclerenchymatous tissues.

I.—Method.

1.—*Determination of the Rate of Water-Loss.*

In considering the exact procedure to be adopted in the determination of the rate of water-loss, two things had to be borne in mind. Under the conditions of high evaporation which frequently prevail in this district it seems probable that the water-content of the leaves of some plants may be further reduced than that of others, and that this might cause differences in the rate of transpiration if the leaves were used immediately after detaching from the parent plant. To

obviate this it was decided always to start with the leaves at their maximum water-content, that is, in the fully turgid condition. This was readily ensured by cutting small twigs from the plant and placing them in water under a bell-jar overnight.

The second point was that the effect of the sclerenchymatous girders was only likely to become apparent as the water-content of the leaf was lowered, that is, as transpiration exceeded absorption. This process (of lowering the water-content) began, however, immediately the leaf was detached from the twig, and its water-supply thus completely stopped. In order to reduce the experimental error, a number of leaves, varying from five to ten, according to their size, were used in each experiment. These were weighed immediately upon removal from the twig, and then at hourly intervals. The earlier experiments were extended over two or three days, and finally the dry weight of the leaves was determined, but later the loss of weight was followed during the first six or seven hours only.

B.—Determination of Sclerenchymatous Tissue.

The most practicable method of determining the amount of sclerenchymatous tissue in the leaves appeared to be, for the purpose of the present investigation, to count the number of "islands" of soft tissue in a given area of leaf surface. This was done by taking a small piece of the leaf to be examined, and counting the total number of islands by the aid of a small dissecting lens. The number of islands in 100 sq. mm. of leaf surface was then calculated. Several counts were made for each leaf, and the average of these was taken as the required result.

The uniformity of the size of these islands over the entire surface of the leaf was tested in the case of *Ptaeroxylon utile* in the following way. The total number of islands in an entire leaflet were counted, and then the area of the leaflet was determined by tracing its outline on squared paper. A small portion was then taken, and the number of islands in it counted and its area determined. From the figures given by the small portion the total number of islands in the whole leaf was calculated, and found to agree, within 1 per cent., with the number obtained by the direct count:—

Number of islands in entire leaflet (direct count) 1343
,, ,, ,, ,, (calculated from portion) 1360

In some leaves it was noticed that the islands of soft tissue have small veins crossing them which do not completely enclose smaller islands, but end before anastomosing with other veins. In these cases it was decided to count portions which were almost completely enclosed and to disregard others. The possible error which may thus be introduced seems unavoidable.

C.—Species Investigated.

The following is a list of the species investigated grouped according to whether they are indigenous to Natal or exotic. Any special features of the leaves likely to affect the rate of water-loss are briefly mentioned.

(i) Indigenous species:

Podocarpus henkelii.—Simple, glabrous leaves; parallel veined.

Portulacaria afra.—A succulent shrub with small, ovate leaves.

Ptaeroxylon utile.—Leaves pinnate; leaflets ovate, glabrous.
Protea roupelliae.—Leaves oblong, hairy on both surfaces.
Trichilia emetica.
Greyia sutherlandi.
Cordia caffra.
Heteromorpha arboresceus.—Leaves palmate, very thin, and flexible.
Bauhinia natalensis.—Leaves hairy on under-surface.
Trema bracteolata.—Leaves slightly hairy.

(ii) Exotic species:

Cedrela toona.
Castanospermum australe.
Hibiscus rosa-sinensis.—Surface of leaves slightly rough.
Grevillea robusta.—Leaves glabrous above or with a few scattered hairs, silky below.
Lasiandra macrantha.—Leaves thickly covered with hairs on both surfaces.
Duvantia plumieri.
Eugenia jambos.
Eugenia eucalyptoides.
Cestrum elegans.—Surface of leaves covered with very short hairs on both sides, particularly along the veins.
Rhododendron indicum.—Lower surface covered with sharp, close-pressed, rigid hairs.
Syncarpia laurifolia.
Petraea volubilis.

II.—Results.

A.—Preliminary Experiments with Leaves Drying at a Constant Temperature.

The early experiments aimed simply at determining the differences in the rate of drying of various leaves without reference to the abundance or otherwise of sclerenchymatous tissue. The results nevertheless appear to be of sufficient interest to warrant their inclusion. The plants used in the first experiment were *Podocarpus henkelii*, *Portulacaria afra*, and *Ptaeroxylon utile*, all of which are growing in the college grounds. Ten leaves of each plant were taken and allowed to dry at a constant temperature of 25° C. in an incubator. The experiment began at 2 p.m. on the 3rd of March, and the leaves were weighed then and at hourly intervals throughout that and the succeeding day. They were then left for two days, and finally dried in a steam oven on the 7th of March. The results are tabulated in the accompanying table (Table I).

Table I.

Time.	*Podocarpus henkelii.*				*Portulacaria afra.*				*Ptaeroxylon utile.*			
	Weight.	Per Cent Turgid Weight.	Water. Content.	Per Cent. Maximum Water. Content.	Weight.	Per Cent. Turgid Weight.	Water. Content.	Per Cent. Maximum Water. Content.	Weight.	Per Cent. Turgid Weight.	Water. Content.	Per Cent. Maximum Water. Content.
3rd March—												
2.5 p.m.	1·4815	100	0·8665	100	6·0860	100	5·6120	100	1·5950	100	0·9870	100
3.5 p.m.	1·4230	96·01	0·8080	93·24	5·9840	98·33	5·5100	98·17	1·3340	83·64	0·7260	73·55
4.5 p.m.	1·3735	92·70	0·7585	87·54	5·9115	97·14	5·4375	96·87	1·2360	77·52	0·6280	63·63
5.5 p.m.	1·3240	89·28	0·7090	81·81	5·8435	96·03	5·3695	95·68	1·1790	73·92	0·5710	57·85
4th March—												
10.5 a.m.	0·8415	56·78	0·2265	26·14	4·9995	82·17	4·5255	80·61	0·6670	41·81	0·0590	5·98
11.5 a.m.	0·8315	56·10	0·2165	24·99	4·9675	81·64	4·4935	80·05	0·6615	41·47	0·0535	5·42
12.5 p.m.	0·8205	55·37	0·2055	23·72	4·9310	81·02	4·4570	79·41	0·6560	41·12	0·0480	4·86
1.5 p.m.	0·8102	54·68	0·1952	22·52	4·8943	80·42	4·4203	78·79	0·6515	40·84	0·0435	4·41
2.5 p.m.	0·7990	53·91	0·1840	21·23	4·8605	79·87	4·3865	78·16	0·6475	40·59	0·0395	4·00
3.5 p.m.	0·7890	53·23	0·1740	20·07	4·8280	79·32	4·3540	77·57	0·6460	40·50	0·0380	3·85
7th March—												
10.50 a.m.	0·6295	42·47	0·0145	1·67	0·4780	7·85	0·0040	0·07	0·6155	38·59	0·0075	0·08
Dry weight	0·6150	41·60	—	—	0·4740	7·79	—	—	0·6080	38·12	—	—

In each case the actual weight of the leaves at the successive intervals is given, and then expressed as a percentage of the fresh weight of the turgid leaves; in the third column is given the water-content of the leaves, obtained by subtracting the dry weight from the live weight, and finally this is expressed as a percentage of the water-content of the turgid leaves.

It should be clearly borne in mind that the experiment essentially consists in suddenly removing the leaves from very favourable conditions, as regards water-supply and diminished transpiration, to extremely unfavourable conditions, the water-supply being completely cut off. It is, therefore, a test of the ability of the leaves to conserve their water when suddenly transferred to severe conditions. In the light of this the figures given for the water-content are of interest. During the first hour the original water-content of the leaves is reduced by 6.76 per cent. in the case of *Podocarpus*, by only 1.83 per cent. in the case of *Portulacaria*, and by the surprisingly large amount of 26.45 per cent. in the case of *Ptaeroxylon*. During the next hour the rate of loss is reduced by about 1 per cent. in the case of *Podocarpus* and *Portulacaria*, whereas in that of *Ptaeroxylon* it is reduced by over 16 per cent. In the third hour the rate of loss in *Ptaeroxylon* has become equal to that in *Podocarpus*, but at the end of this time the former has lost over 40 per cent. of its original water-content, while the latter has lost a little less than 20 per cent. The relatively large check on the rate of loss in *Ptaeroxylon* is very well shown in the accompanying figure, where the rates of loss over the first three hours are plotted separately. (Fig. 1v.) Whether this decrease in the rate is to be attributed to stomatal closure or simply to the lowering of the water-content has not as yet been definitely settled, but the question is receiving attention in connection with a more intensive study of the water relations of these three plants.

During the second day the rate of loss averaged about 0.5 per cent. per hour in the case of *Portulacaria* and *Ptaeroxylon*, and about 1.25 per cent. in the case of *Podocarpus*. It is of interest to note that twenty-four hours after the commencement of the experiment *Portulacaria* still retained 77.5 per cent. of its water, *Podocarpus* 20 per cent., and *Ptaeroxylon* only 4 per cent.

The figures given here should be compared with those given in Section II of this memoir—"A New Calcium Chloride Method of Measuring Resistance to Water-Loss in Leaves." These also support the conclusion that *Portulacaria afra* is more resistant to water-loss than *Ptaeroxylon utile*, though apparently the difference is less pronounced while the leaves remain attached to the parent plant than when they are removed.

In the second experiment the species used were *Podocarpus elongata*, *Protea roupelliae*, *Crassula* sp., and *Greyia sutherlandi*. These were all growing on the slopes of the Zwartkop, a mountain near Maritzburg; twigs were brought into the laboratory and left in water under a bell-jar overnight. As in the previous experiment, the leaves were weighed when fully turgid, and then kept in an incubator at a constant temperature of 25° C., and weighed at hourly intervals throughout the first two days. The dry weight was finally determined on the third day. The results are tabulated in Table II in the same way as in the previous experiment.

Table II.

Time in Hours.	*Podocarpus elongata.*				*Protea roupelliae.*				*Crassula* sp.				*Greyia sutherlandi.*			
	Weight.	%	Water-Content.	%	Weight.	%	Water-Content.	%	Weight.	%	Water-Content.	%	Weight.	%	Water-Content.	%
0	1·4245	100	0·7420	100	—	—	—	—	2·9930	100	2·5300	100	—	—	—	—
1	1·3860	97·27	0·7035	94·82	5·1180	100	3·4560	100	2·8995	96·87	2·4365	96·32	12·3900	100	8·2200	100
2	1·3520	94·86	0·6695	90·22	4·9570	91·45	3·2950	95·35	2·8205	94·26	2·3575	93·24	11·3300	96·85	7·1600	87·10
3	1·3220	92·76	0·6395	86·18	4·8200	86·46	3·1580	91·37	2·7645	92·39	2·3015	90·97	10·7100	94·17	6·5400	79·56
5½	1·2585	88·35	0·5760	77·62	4·5330	78·21	2·8710	83·07	2·6485	88·51	2·1855	86·40	9·6910	88·57	5·5210	67·16
22	0·9950	69·82	0·3125	42·12	2·7300	48·91	1·0680	30·90	2·1790	73·82	1·7160	67·82	6·0580	53·34	1·8880	23·02
23	0·9780	68·63	0·2955	39·82	2·5840	47·12	0·9220	26·68	2·1550	71·96	1·6920	66·88	5·8370	50·49	1·6670	20·28
24	0·9640	67·66	0·2815	37·94	2·4875	45·84	0·8255	23·89	2·1385	71·47	1·6755	66·24	5·6800	48·64	1·5100	18·37
25	0·9470	66·45	0·2645	35·65	2·3630	44·41	0·7010	20·28	2·1105	70·53	1·6475	65·12	5·5010	46·17	1·3310	16·19
26	0·9360	65·69	0·2535	34·17	2·2720	43·37	0·6100	17·65	2·0920	69·88	1·6290	64·39	5·3730	44·39	1·2030	14·63
27	0·9230	64·77	0·2405	32·41	2·1830	42·38	0·5210	15·08	2·0745	69·34	1·6115	63·69	5·2550	42·66	1·0850	13·20
28	0·9095	63·83	0·2270	30·59	2·0975	41·72	0·4355	12·71	2·0570	68·74	1·5940	63·01	5·1680	41·00	0·9980	12·14
29	0·9000	63·16	0·2175	29·32	2·0410	41·20	0·3790	10·96	2·0450	68·32	1·5820	62·55	5·1040	39·87	0·9340	11·36
Dry weight	0·6825	47·89	—	—	1·6620	33·20	—	—	0·4630	15·47	—	—	4·1700	32·47	—	—

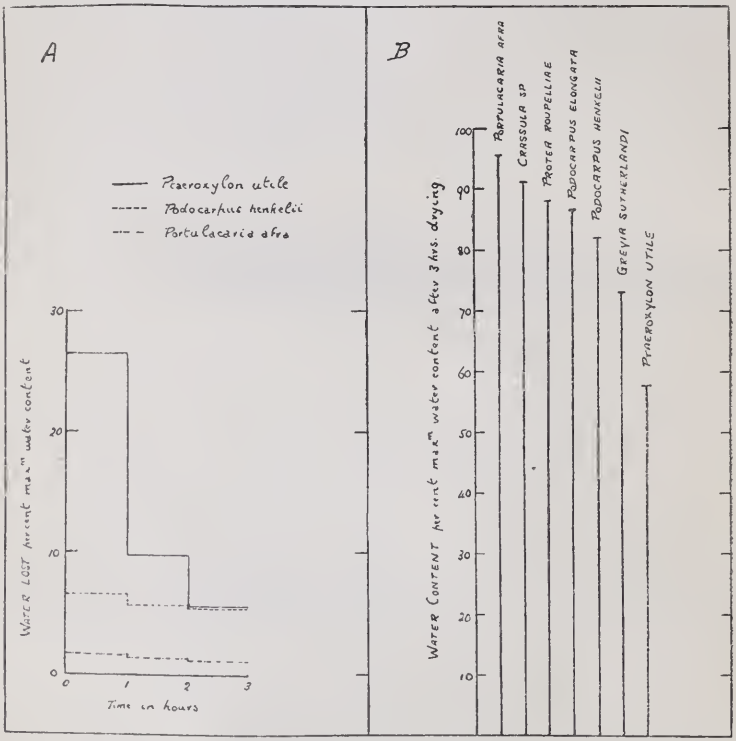
Comparing first of all the figures for the first hour, it will be noted that the reduction of the water-content is as follows:—

Podocarpus 5.18 per cent.; *Protea* 4.64 per cent.; *Crassula* 3.68 per cent.; *Greyia* 12.90 per cent.

During the next hour the rate of loss was—

Podocarpus 4.60 per cent.; *Protea* 3.98 per cent.; *Crassula* 3.08 per cent.; *Greyia* 7.54 per cent.

As in the previous experiment, it will be noticed that the succulent loses water least rapidly of all. The low rate in *Protea* is



Section IV.—Fig. 1.

A.—Showing water lost per hour per cent. maximum water-content.
B.—Showing "water balance" per cent. maximum water-content after three hours' drying.

probably attributable to the covering of hairs on both surfaces. *Greyia sutherlandi* loses very rapidly during the first hour, but then checks the rate of loss, which soon becomes about equal to the rate of loss in *Podocarpus*.

It is interesting to compare the amounts of water left in the leaves after twenty-four hours. In *Crassula* it is as high as 66 per cent.; *Podocarpus* comes next with 38 per cent.; then *Protea* with 20 per cent., and finally *Greyia* with only 16 per cent. The difference between the succulent and the other plants is even more striking on

the third day (not included in the above table). Just before the dry-weight determination was made the amount of water remaining in the leaves, expressed as a percentage of the original water-content, was—

Podocarpus 16 per cent.; *Protea* 5 per cent.; *Crassula* 52 per cent.; *Greyia* 7 per cent.

Since these first two experiments were carried out with the leaves in an incubator at a constant temperature, the results for all seven plants may be fairly compared. If the decrease in water-content during the first three hours of drying is considered, we obtain the following table:—

Table III.

Species.	Reduction in Water-Content.
	Per Cent.
Portulacaria afra	4·32
Crassula sp.	9·03
Protea roupelliae	12·00
Podocarpus elongata	13·82
Podocarpus henkeli	18·19
Greyia sutherlandi	27·00
Ptaeroxylon utile	42·15

If the loss in twenty-four hours be considered, the only alteration necessary is that the *Protea* comes below the two *Podocarps* instead of above. It is worth noting that if one were to write down these species in the order of increasing mesophytism, the list would probably be identical with the above.

Of the plants used in these two experiments, four were unsuitable for the determination of the amount of sclerenchyma by the present method, these being the two succulents and the two *Podocarps*. The remaining three appear to have about the same number of "islands" per unit area of leaf-surface, the actual figures per sq. cm. being *Greyia sutherlandi* 562, *Protea roupelliae* 669, and *Ptaeroxylon utile* 672; consequently the differences in the rate of loss must be attributed to other structural features, for example, the hairs on the *Protea* leaves to which reference has been made above.

These two experiments are admittedly more suggestive than conclusive, and it is hoped to analyse the problems raised more deeply in the near future. They certainly demonstrate very clearly that under conditions of extreme scarcity of water—actually in this case with the water-supply completely cut off—succulents have a greater power of resisting water-loss, and consequently are able to maintain a large water-balance for a much longer period than non-succulents. They also suggest that *Podocarpus* spp. are more resistant to water-loss than dicotyledonous plants, even though the latter usually occur in far drier and more exposed situations than the former.

B.—Experiments on the Relation between Resistance to Drying and the Amount of Sclerenchyma in the Leaves.

In this series of experiments groups of three or four plants were used in each experiment, an endeavour being made to include in each group leaves differing widely in the abundance of sclerenchyma present. In every case the leaves were first rendered fully turgid, and then detached from the twig and allowed to dry under ordinary atmospheric conditions. The loss of weight was followed hour by hour for a period of seven hours in each case (except No. 3). To avoid

unnecessary confusion, the results of each experiment and the discussion of them are presented separately.

Experiment No. 3.—Species used: *Ptaeroxylon utile, Cordia caffra, Heteromorpha arborescens.*

Table IV.

Time in Hours.	*Ptaeroxylon utile.*			*Cordia caffra.*			*Heteromorpha arborescens.*		
	Weight.	Per Cent. Turgid Weight.	Loss of Weight per Cent. Fresh Weight per Hour.	Weight.	Per Cent. Turgid Weight	Loss of Weight per Cent. Fresh Weight per Hour.	Weight.	Per Cent. Turgid Weight.	Loss of Weight per Cent. Fresh Weight per Hour.
0	2·3250	100	20·51	2·2950	100	42·23	2·6270	100	13·20
1	1·8480	79·49	14·28	1·3215	57·77	20·69	2·2800	86·80	19·72
2	1·5180	65·21	0·44	0·8510	37·08	0·57	1·7620	67·08	2·37
3	1·5055	64·77	0·55	0·8380	36·51	0·61	1·7000	64·71	2·85
4	1·4930	64·22	0·42	0·8240	35·90	0·36	1·6250	61·86	1·62
5	1·4825	63·80	0·57	0·8155	35·54	0·29	1·5820	60·24	1·91
6	1·4700	63·23		0·8090	35·25		1·5320	58·33	
Total loss per cent. fresh weight....			36·77			64·75			41·67

Two points seem worth noting in the above: (i) The very marked falling off in the rate of loss which becomes apparent in each case during the third hour. The probable explanation of this is the extreme reduction of the water-content. Assuming the dry weight of *Ptaeroxylon utile* to form the same percentage of the turgid fresh weight as in the first experiment, viz., 38.12 per cent., the loss of water in two hours expressed as a percentage of the water-content is well over 50 per cent., and one would certainly expect the stomata to have closed long before so serious a depletion of the water-balance. The question is one which is receiving further attention. (ii) The increase in the rate of loss in *Heteromorpha* during the second hour. This may possibly be connected with a stomatal opening before wilting, but in the light of Knight's recent work (2) one would expect this to take place long before so large a decrease in weight as 13 per cent. of the fresh weight.

Considering next the possible relationship between the rate of loss of water and the abundance of sclerenchyma, the number of islands of soft tissue per sq. cm. of leaf-surface are—

Ptaeroxylon utile 644; *Heteromorpha arborescens* 1051; *Cordia caffra* 212.

Comparing first of all *Ptaeroxylon* and *Cordia*, it is interesting to find that the latter, with about a third as many "islands" as the former, loses water nearly twice as rapidly, especially during the first hour. *Heteromorpha*, on the other hand, with by far the largest number of "islands," loses far more water in the course of six hours than does *Ptaeroxylon*. It must be remembered, however, that while the leaves of *Ptaeroxylon* and of *Cordia* are fairly small and somewhat leathery in their texture, those of *Heteromorpha* are much larger, thinner, and more flexible, and are, therefore, not strictly comparable

with those of the other two. Possibly the abundance of sclerenchyma does affect the rate of loss from these leaves, but not sufficiently to make it less than that from tough leaves like those of *Ptaeroxylon*, also well provided with sclerenchyma.

Experiment No. 4.—Species used: *Cedrela toona, Bauhinia natalensis, Trichilia emetica, Trema bracteolata.*

TABLE V.

Time in Hours.	*Bauhinia natalensis.*			*Trichilia emetica.*			*Cedrela toona.*			*Trema bracteolata.*		
	Weight.	Per Cent. Turgid Weight.	Loss of Weight.	Weight.	Per Cent. Turgid Weight.	Loss of Weight.	Weight.	Per Cent. Turgid Weight.	Loss of Weight	Weight.	Per Cent. Turgid Weight.	Loss of Weight.
0	2·575	100	8·36	3·743	100	5·39	1·485	100	1·69	3·135	100	7·70
1	2·360	91·64		3·5406	94·61		1·460	98·31		2·893	92·30	
2	2·180	84·67	6·97	3·434	91·75	2·86	1·436	96·68	1·63	2·696	86·02	6·28
3	2·058	79·93	4·74	3·388	90·51	1·24	1·401	94·32	2·36	2·464	78·59	7·43
4	1·960	76·12	3·81	3·3554	89·62	0·89	1·379	92·85	1·47	2·280	72·73	5·86
5	1·873	72·73	3·39	3·326	88·86	0·76	1·3556	91·28	1·57	2·090	66·67	6·06
6	1·797	69·79	2·94	3·300	88·16	0·70	1·336	89·95	1·33	1·958	62·46	4·23
7	1·740	67·56	2·23	3·280	87·64	0·52	1·319	88·59	1·36	1·911	60·95	1·51
Total loss per cent. fresh weight	—	—	32·44	—	—	12·36	—	—	11·41	—	—	39·05
No. of "islands" per sq. cm.	—	—	1·449	—	—	634	—	—	798	—	—	499

Trichilia emetica is the only species in this group which shows any considerable reduction in the rate of loss during the second hour. In the others there is a slow, though steady, reduction in the rate throughout the seven hours. Possibly this is due to the fact that the rate of loss during the first hour was much smaller than in the case of *Greyia sutherlandi* and *Ptaeroxylon utile* in the previous experiment.

As in the last experiment the species with the smallest amount of sclerenchyma—*Trema bracteolata*—loses the greatest amount of water. *Cedrela toona* and *Trichilia emetica* with larger amounts of sclerenchyma show a considerably lower rate of loss, but *Bauhinia natalensis* with the largest amount shows a loss nearly as great as that from *Trema bracteolata*.

Experiments Nos. 5, 6, and 7.—In the three concluding experiments leaves of plants growing in the Botanic Gardens, Maritzburg, were used, and our thanks are due to the curator, Mr. H. H. Kidd, for permission to gather the material and for assistance in its identification. Four species were used in each experiment. As before, the leaves were grouped in bundles, and several bundles of each kind were used and the averages calculated for each hour.

No. 5.—Species used: *Castanospermum australe, Hibiscus rosa-sinensis, Grevillea robusta. Lasiandra macrantha.*

Table VI.

Species.	Loss of weight per cent. fresh weight in 7 hours.	No. of sclerenchyma "islands" per sq. cm.
Castanospermum australe	13·28	1,478
Hibiscus rosa-sinensis	16·13	655
Grevillea robusta	25·27	677
Lasiandra macrantha	41·09	379

This experiment affords more support than any of the foregoing for the theory of a possible interrelationship between the sub-division of the lamina of the leaf into numerous "islands" of soft tissue and the rate of loss of water. *Castanospermum* with the greatest number of "islands" loses least, while *Lasiandra* with the smallest number loses most, the other two species being intermediate in both respects.

No. 6.—Species used: *Eugenia jambos, Eugenia eucalyptoides, Durantia plumieri, Cestrum elegans.*

Table VII.

Species.	Loss of weight per cent. fresh weight in 7 hours.	No. of sclerenchyma "islands" per sq. cm.
Eugenia jambos	7·3	1,050
Eugenia eucalyptoides	8·25	1,125
Durantia plumieri	32·78	931
Cestrum elegans	47·80	266

In this, as in the previous experiment, those leaves with the smallest number of "islands" show the highest percentage loss of weight, those with the greatest number show the lowest.

No. 7.—Species used: *Rhododendron indicum, Syncarpia laurifolia, Petraea volubilis.*

Table VIII.

Species.	Loss of weight per cent. fresh weight in 7 hours.	No. of sclerenchyma "islands" per sq. cm.
Rhododendron indicum	11·63	697
Syncarpia laurifolia	17·04	754
Petraea volubilis	34·84	598

The leaves of these three species show very little difference as regards the amount of sclerenchyma present, but they show considerable differences in their loss of weight. The difference between *Rhododendron* and *Petraea* in this respect is 22 per cent., though the former contains only 100 more "islands" per sq. cm. than the latter; this difference is almost as great as that between *Castanospermum* and *Lasiandra* in the previous experiment (27.7 per cent.), yet the former contained over 1,000 more "islands" per sq. cm. than the latter. *Eugenia eucalyptoides* and *Cestrum elegans*, on the other hand, differed by nearly 40 per cent. for a difference of rather less than 1,000 "islands" per sq. cm.

In view of these facts, the experiments described in the present section of this paper, viz., Nos. 3, 4, 5, 6, and 7, cannot be regarded as affording conclusive evidence that the sub-division of the lamina of the leaf into minute "islands" of soft tissue by numerous fine veins tends to check the rate of loss of water during the drying of leaves. Before a final proof can be obtained, account must be taken of many other factors, such as the thickness of the cuticle, texture of the leaf, and the distribution and behaviour of the stomata. At the same time it is certainly suggestive to find that in each experiment the leaves with the fewest "islands" show the highest rate of loss. In several of the experiments it is also clear that leaves with a large number of very small "islands" lose least rapidly, but this apparently is not invariably the case. A comparison of the rate of water-loss from different leaves by similar methods to those used in the present investigation, together with a careful study of their chief structural features, will, it is hoped, be commenced shortly and may be expected to throw more light upon the results so far obtained.

Summary and Conclusions.

1. Experiments on the rate of drying of detached leaves of various species indicate—

(*a*) that succulents have a greater power of resisting water-loss and consequently are able to maintain a large water-balance for a much longer period than non-succulents;

(*b*) that leaves of *Podocarpus* spp. are more resistant to water-loss than are dicotyledonous leaves, even though the latter are from plants growing in much drier and more exposed situations than the former.

2. Leaves of dicotyledonous plants vary considerably in the abundance and arrangement of their woody tissues. In some, the lamina of the leaf is divided into a few large "islands" of soft tissue

by the lateral veins, while in others it is divided into numerous minute "islands." The possibility of this exerting a considerable influence on the rate of water-loss is discussed.

3. In the experiment described, leaves with large "islands" of soft tissue showed the highest rates of loss. Leaves with numerous small "islands" usually showed low rates of loss, but this was not invariably the case.

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SECTION V.

The Distribution and Ecology of the Genus *Cussonia* (Thunb.), with some Remarks upon its Probable Evolutionary History.

Recent ecological studies in the midlands of Natal have shown the widespread occurrence and the important part played in the plant succession by *Cussonia spicata* (1). In connection with these investigations it appeared probable that a comparative study of the various species, particularly with regard to their distribution and ecology, would afford interesting information as to the course of evolution within the genus. Work on these lines was commenced early in 1922, but owing to the claims of other matters, had to be abandoned after a few months, and since then no favourable opportunity for resuming it has presented itself. The facts already gathered, however, are of some interest, and it was therefore considered advisable to publish them in the present memoir.

The genus as defined by Harms (7) in Engler's "Pflanzenfamilien" consists of some twenty-two or twenty-three species, confined to Southern and Tropical Africa, Madagascar, and the Comoro Islands. The species are all trees or shrubs with large, lobed, or palmately compound leaves, the leaflets themselves being frequently further divided. The South African species, particularly, have more or less deeply divided leaflets, the primary leaflets often bearing several secondary leaflets. The flowers are sessile or pedicellate, usually in spikes or racemes, often with thick, club-shaped axes, arranged in umbels or racemes at the ends of branches. The pedicels, when present, are not jointed to the flowers as in *Panax*, another African genus of the *Araliaceae*, and the ovary is two-celled, a character which distinguishes it from a third genus, *Heptapleurum*, occurring in tropical Africa, which has a five or many celled ovary. The ruminate endosperm of the seed is another striking characteristic of the genus.

I.—Classification.

The genus is sub-divided by Harms (7) into two sub-genera, dependent upon the character of the inflorescence, viz.:—(i) *Eucussonia*, in which the flowers are arranged in spikes or racemes; and (ii) *Neocussonia*, with the flowers in umbels. He remarks that he would very much like to limit the genus to those species whose flowers

are arranged in spikes or racemes. " Those with umbels I still class under *Cussonia* for the present, as they are imperfectly known to me, and I am therefore still in doubt whether they have so much in common; whether, for instance, they all have a ruminate endosperm, so that they may be collected into one genus. *C. umbellifera* (Sond.) has nearly all essential distinctions in common with *Didymopanax*. Certain *Cussonia* species of the group *Neocussonia* show relations to several *Schefflera* species of New Caledonia, which are characterized only by ovary with three to four cells." Of the two sections, *Eucussonia* is the larger, with sixteen species, two of which are confined to Madagascar. *Neocussonia* contains five species, of which three are endemic in Madagascar. Of the remaining two, *C. umbellifera* occurs along the coast-belt of Natal. C. *gerrardi* (Seem) is also recorded by Harms for Natal, but there does not appear to be any other record of this species. It may possibly be identical with *Panax gerrardi* (Harv.), which occurs in the midlands of Natal.

The following dichotomous key to the species has been drawn up from the descriptions given by Harms (7) and those in the " Flora Capensis " (8) and " Flora of Tropical Africa " (11):—

1. Flowers in spikes or racemes (*Eucussonia*) 2
   Flowers in umbels (*Neocussonia*) 16
2. Leaves lobed, but not compound 3
   Leaves palmately compound 6
3. Leaves indented at the margin only; serrate 4
   Lobes ± deeply indented, leaves with rough scattered hairs
   C. laciniata (Harms).
4. Leaves cleft to ½–1 in. from petiole (i.e. nearly compound with sessile leaflets); tomentose ... ... *C. arborea* (Hochst.).
   Leaves not as deeply cleft as in *C. arborea* 5
5. Leaves deeply indented; lobes united by a half-uncial lamina. Leaves without hairs ... ... *C. natalensis* (Sond.).
   Lobed to middle of leaf. Leaf with rough, scattered hairs.
   C. hamata (Harms).
6. Flowers sessile, closely massed together on petiolate, thick, club-shaped spikes ... ... *C. spicata* (Thunb.).
   Flowers pedicellate, or, if sessile, then flowers loosely arranged at least in lower part of spike 7
7. Flowers sessile 8
   Flowers pedicellate 13
8. Leaflets sessile 9
   Leaflets with short or long petioles... 11
9. Spikes arranged bushily. Leaflets entire ... ... *C. vantsilana* (Baker).
   Spikes numerous, standing conspicuously among the leaves at the ends of branches 10
10. Leaflets serrately notched ... ... *C. kirkii* (Seem.).
    Leaflets with entire margin ... ... *C. barteri* (Seem.).
11. Leaflets entire margined or pinnatifid. Flowers in spikes, arranged in racemes ... ... *C. paniculata* (E. and Z.).
    Leaflets with long petioles; margins notched or serrate 12
12. Leaflets oblong ... ... *C. holstii* (Harms).
    Leaflets ovate. Spikes small in umbelled racemes .. *C. microstachys* (Harms).
13. Leaflets ± long petioled 14
    Leaflets sessile 15
14. Leaves as in *C. spicata* (i.e. leaflets bearing secondary leaflets), but not narrowed at apex ... ... *C. kraussii* (Hochst.).
    Leaves not as in *C. spicata*; much acuminato or sub-caudate at apex.
    C. angolensis (Seem.).
15. Leaflets wedge-shaped, with entire margins ... ... *C. racemosa* (Baker).
    Leaflets obovate, or wedge-shaped, sparsely serrate, undivided or deeply indented, often three-lobed ... ... *C. thyrsiflora* (Thunb.).
16. Leaves simple... 17
    Leaves compound 18

17. Leaves simple, obovate-oblong ... ... *C. monophylla* (Baker).
Leaves lobed, palmatifid ... ... *C. gerrardi* (Seem.).
18. Leaflets sessile ... ... *C. bojeri* (Seem.).
Leaflets petiolate... 19
19. Umbels arranged in racemes ... ... *C. umbellifera* (Sond.).
Umbels in another umbel... ... ... *C. myriantha* (Baker).

From the above, a short key to the South African species can be constructed as follows :—

1. Flowers in spikes or racemes 2
Flowers in umbels... 6
2. Flowers pedicellate 3
Flowers sessile 4
3. Leaflets often bearing secondary leaflets ... ... *C. kraussii.*
Leaflets usually deeply divided and three-lobed, but without secondary leaflets ... ... *C. thyrsiflora.*
4. Leaves palmatifid, not compound ... ... *C. natalensis.*
Leaves palmately compound 5
5. Flowers in thick, club-shaped spikes, arranged in umbels ... ... *C. spicata.*
Flowers in spikes, arranged in racemes ... ... *C. paniculata.*
6. Leaves palmatifid ... ... *C. gerrardi.*
Leaves palmately compound ... ... *C. umbellifera.*

Up to the present time the writer has been unable to obtain descriptions or material of any of the Madagascan species or of the following tropical African species:—*C. laciniata*, *C. hamata*, *C. holstii*, *C. microstachys*, consequently the above key may not be entirely satisfactory. It certainly suggests that the differences between many of the species are very slight. The principal characters used in the division of the genus are those of the inflorescence, but many of the distinctions between the species are based entirely upon leaf characters. As will be shown later these vary greatly in the individual species examined, and in many cases even on one tree, and consequently one is rather doubtful as to the value of such distinctions as those given, for example, under 8 and 13 in the above key.

Again, the four species of the *Eucussonia* group with palmatifid, but not compound, leaves appear to be distinguished principally by the depth of leaf division, although *C. laciniata* and *C. hamata* differ from *C. arborea* and *C. natalensis* in the presence on the leaves of rough, scattered hairs, and *C. arborea* differs from *C. natalensis* in being softly tomentose. In any case the species with simple leaves appear to be very closely related to one another, and from the descriptions given it seems possible to arrange them in a series showing increasing leaf division. Thus, *C. hamata* and *C. natalensis* both have palmatifid leaves, rather deeply lobed, the margins of the lobes being serrate; in *C. laciniata* the lobes are themselves deeply indented; in *C. arborea* the lobes are divided almost to the petiole, so that the leaf is very nearly compound, the margin of the lobes, as in *C. hamata* and *C. natalensis* being serrate. Very close to *C. arborea* is *C. kirkii* with palmately compound leaves, the serrate leaflets of which are sessile. Harms himself draws attention to the close relationship between these two species.

II.—Distribution and Ecology.

One of the primary objects of the investigation was to gain as complete an idea as possible of the geographical distribution of the various members of the genus. A large number of local floras and check-lists have been consulted, and from these it has been possible

to gain a fairly accurate idea of the approximate limits reached by each species and in a few cases to specify the region of greatest abundance. In the following account the various species are dealt with in order of the size of the area occupied, those with the widest distribution being taken first:—

C. spicata.—This is by far the most widely distributed species, extending from tropical Africa to the Eastern Province in the Cape. It has also been recorded from the Comoro Islands. Its northern limit appears to be in the Mozambique District, while in the Cape it does not occur south of Port Elizabeth. Thus it extends along the whole eastern side of the continent approximately between latitudes 15° and 34° S. That its distribution is practically continuous within these limits is shown by its being recorded from Portuguese East Africa (16), Gazaland (18), Southern Rhodesia (5), Transvaal and Swaziland (4), Natal (2), Kaffraria (14), Uitenhage and Port Elizabeth (13). It is particularly abundant in the midlands of Natal, where it forms a conspicuous feature of much of the hillside vegetation, but it also occurs on the Drakensberg and along the coast-belt. In his "Forest Flora of Portuguese East Africa" (16), Sim states that "it is seen occasionally, but rarely, in M'Chopes and Magenja da Costa; is more frequent in the Lebombo Range and plentiful in Natal and the Cape."

The ecology of this species is of special interest since it occurs in two very distinct habitats and formations. On many of our hillsides with northern exposure it acts as the chief pioneer in the establishment of tree-veld, and the writer has elsewhere analysed and described the succession thus initiated (1). When growing in these situations, *C. spicata* is a large and much-branched tree, branching frequently taking place from near the base. Throughout the midlands, particularly between Maritzburg and the coast, there are many of these hillsides, covered with scattered clumps of bushes, characteristic of tree-veld, in which this tree is usually prominent.

The other type of habitat occupied by *C. spicata* is on slopes with southern exposure, covered with close bush. It may occur on the edge of the bush, when its growth-form is very similar to that in the open tree-veld, but frequently it is found right in the centre of close bush, and in this case it forms a very long and usually unbranched trunk. This often reaches a great height and bears a large crown of leaves far above the tops of the surrounding trees. In much of the bush near Maritzburg numbers of these trees are present, and their long unbranched trunks and leafy tops seldom fail to attract attention. The possibility of these two forms being in reality distinct species may be suggested, but except for this difference in the branching they are very similar. More probably the difference between the two growth-forms is caused by the difference in the succession in the two types of formation. In tree-veld, *C. spicata* is the pioneer, and germinates and grows in the open veld. Shrubs and trees come in later and grow in the shade of the pioneer, which, having a good start, always overtops the surrounding vegetation. The early stages of bush, on the other hand, are characterized by the presence of dense masses of tall shrubs, which are followed by numerous trees, no one of which has a clear start, as is the case in tree-veld. The production of a long unbranched trunk may therefore be a response to the need for light, which is met by keeping the leaves well above the level of the surrounding vegetation.

The seeds are almost certainly distributed by birds, passage through the body of which is probably necessary to soften the very hard seed-coat and start germination. In the field it is extraordinary how few young plants are found; despite many careful searches in the neighbourhood of clumps and bush in which *C. spicata* is present, the writer can recall only one instance in which he has discovered a really young plant. This is probably due to the very low germination capacity of the seeds. The removal of the seed-coat facilitates germination, but even then very few seeds germinate. Thus, in one experiment in which ten carefully chosen seeds were planted, after the removal of the seed-coat, only three germinated in the course of a month, and of these only one survived for any length of time. This low germination capacity of the seeds is somewhat surprising in a plant of such wide distribution and frequent occurrence, particularly as the seeds of some of the other species germinate much more readily under similar conditions. Not only does a considerable percentage of the seed fail to germinate, but only a small number of the flowers set good seed. In addition to this, there are frequently clear indications that many of the seeds are destroyed by insects. With a view to obtaining clearer ideas on this question, counts were made of the total number of flowers on a spike and of the number of good seeds produced. The following is a typical instance of a spike obtained from a healthy tree growing near Maritzburg. There were in all 392 flowers on this spike, and as each flower produces two seeds, this meant a potential output of 784 seeds. The number of apparently good seeds obtained, however, was only 171; that is, only 22 per cent. of the possible number.

It is worth noting here that all the species possess considerable powers of regeneration, young shoots frequently being formed from the base of the trunk and the underground system. A particularly good instance of this was noticed on the southern slopes of Signal Hill. In this locality it is fairly clear that there existed at one time a patch of close bush, which has been destroyed by fire. At the present time it is covered by very tall shrubs and a few young trees, forming an early stage in the succession towards bush. Scattered amongst these shrubs are what appear to be several young trees of *C. spicata*, but closer examination reveals the fact that they have all been formed from the large stumps of much older trees, which were apparently destroyed along with the original bush.

C. paniculata.—This is another species of fairly wide range, though much more restricted in its distribution than is *C. spicata*. It is recorded from the Transvaal (4), Natal (2), Basutoland (12), Kaffraria (14), Queenstown, Cathcart, and Maclear (15), Somerset East, and Beaufort West (12). It is confined to higher altitudes than is *C. spicata*, and in Natal does not occur below Ladysmith. It is fairly common in the Transvaal and extends southwards right along the chain of the Drakensberg to Beaufort West. According to Sim's "Forest Flora of Cape Colony" (15), "it occurs in many parts of the Karroo and semi-carroid scrub, and in Queenstown, Cathcart, Maclear, and other higher districts seldom below 2,000 feet altitude." It is a distinctly tree-veld species, and does not occur in close bush at all. Around Ladysmith and Pretoria it is very abundant on rocky hillsides. In the former district the hillsides and slopes of the valleys are frequently strewn with large boulders, which become intensely

hot during the day, and must radiate a considerable amount of heat. The temperature in these valleys is very high, and they present a very arid and decidedly xerophytic appearance. Aloes are common on many of these slopes, and *C. paniculata* appears to thrive. It is certainly commoner here than in the cooler, moister regions higher in the Drakensberg; for example, at Van Reenens Pass.

The seeds of this species germinate much more readily than do those of *C. spicata*. As before, the removal of the seed-coat considerably facilitates germination. Thus, in an experiment contemporaneous with that already described for *C. spicata*, fifty-two seeds, picked up under a tree near Ladysmith, were planted, the seed-coats having first been removed from twenty-six of them. After a month, twenty-one of the latter had germinated; that is, 80 per cent. as compared with 30 per cent. in the case of *C. spicata*. Of the twenty-six from which the seed-coat was not removed, only four germinated in the same period; that is, only 15 per cent.

C. umbellifera.—The distribution of this species is roughly parallel to that of *C. paniculata*, but in Natal it is confined to the coast-belt, whereas the latter is a distinctly mountain type. It is recorded from Southern Rhodesia (5 and 9), Transvaal and Swaziland (4), Natal (2), and Kaffraria (14), the region of greatest abundance probably being in the Chimanimani Mountains, on the eastern border of Southern Rhodesia. In Natal it is fairly common in coast-belt bush, but does not occur in the more open tree-veld. A fairly clear idea of the ecology of the species can be gained from the following accounts. In "Forestry in Southern Rhodesia" (9), J. S. Henkel states that there are two main types of forest growth, viz., (1) high or close type forest, and (2) savannah forest (tree-veld). One of the types of high forest is "the evergreen forest of the upper mountain slopes with trees up to 80 feet in height with *C. umbellifera* and *Eugenia* spp. dominant. The high forests are confined to the narrow mountain ranges on the eastern border with an annual precipitation of 50 inches to 80 inches." Describing the Chimanimani Mountains in his "Flora of Gazaland" (18), C. F. M. Swynnerton says: "The mountain forests are dense and rich and composed largely of evergreen trees. The trees average little more than 40 feet in height, and the most characteristic are the large, dark-leaved *C. umbellifera*, etc." With regard to its occurrence in the Union of South Africa, Sim writes in his "Native Timbers of South Africa" (17) as follows:—"*C. umbellifera*.—A spreading, evergreen tree, 40 to 50 feet high, often with a clean stem half that height, of 12 to 24 inches diameter, and numerous large branches. Abundant in the outskirts or less dense parts of the forest in the Transkei and Pondoland within a few miles of the coast and extending farther inland in Natal, but usually where free from frost. It occurs also abundantly in the eastern Transvaal, but was not noted by me in Portuguese East Africa. It usually occurs in best form on rock débris below krantzes where it has shelter; it is seldom in actual forest, but often intermingled in scrub, and is shown as forming 2 per cent. of the utilizable stand in the rocky Ngoya Forest, Zululand." Judging from these accounts we may conclude that the species is distinctly sub-tropical and is confined to the mesophytic habitat, in which close bush commonly occurs. It is commonest in

the tropical regions, forming a prominent member of the close forest, and gradually becomes less abundant towards the south, until in the Transkei it is confined to a narrow strip of coast-belt.

C. thyrsiflora.—This is the southernmost species of the genus, occurring in the Western Province of the Cape. It extends from the Districts of Uitenhage and Port Elizabeth (13), which it will be remembered constitute the southern limit of *C. spicata*, right round to the Cape Peninsula. This south-western region is probably the most xerophytic of all those in which *Cussonia* species occur, with winter rains, dry hot summers, and an annual rainfall of 20 to 30 inches. It is fairly abundant in the scrub, occurring in many of the ravines on Table Mountain and throughout the Peninsula.

The remaining species are much less widely distributed and can be dealt with very briefly. *C. kraussii* occurs on the coast-belt of Natal in open tree-veld. It very closely resembles *C. spicata* except for the pedicellate flowers. *C. natalensis* has a curiously discontinuous distribution. It was collected at Inanda, on the coast-belt of Natal, by Medley Wood, and on the Matopo Hills, in Southern Rhodesia, by Miss Gibbs (6), who describes it as "a small tree flowering before the leaves." It is also recorded by Burtt-Davy in his "Check-List of the Flowering Plants and Ferns of the Transvaal and Swaziland" (4), but no locality is given. No other record has so far been discovered; the plant is evidently rare and does not seem to occur in the midlands of Natal.

Of the tropical species, the northernmost is *C. arborea*, collected by Schimper in Abyssinia. According to Harms, *C. hamata* and *C. laciniata* occur in Gazaland, but they are not mentioned by Swynnerton (18). *C. kirkii* occurs in the Mozambique District, *C. holstii* in Usambara, and *C. microstachys* in Somaliland. There are only two western species—*C. barteri* in Nigeria and *C. angolensis* in Angola. One other South African species may be mentioned. *C. chartacea* (Schinz) is recorded for the Transvaal and Natal, but is only known in the sterile condition. Five species occur in Madagascar, of which two—*C. vantsilana* and *C. racemosa*—belong to the *Eucussonia* section, and three—*C. monophylla*, *C. bojeri*, and *C. myriantha*—to the *Neocussonia* section.

III.—External Morphology.

All the species actually examined by the present writer possess a large underground tuber, which is infested with the hyphae of an endophytic fungus. In seedlings of *C. spicata* and *C. paniculata* this tuber can be observed forming at a very early stage after germination by the swelling of the hypocotyl, and fungal hyphae have been found even in very young tubers of *C. paniculata*.

The stems and branches of *C. spicata* and *C. paniculata* are very thick and soft owing to the formation of a large pith and cortex. In *C. thyrsiflora* and *C. umbellifera* the stems are much thinner, but harder, the thickness of the secondary wood being much greater in proportion to that of the pith and cortex than in the two first-named species. The trunks and branches of *C. spicata* and *C. paniculata* are covered with a very thick bark, which probably accounts for their ability to grow in the open veld and withstand, to some extent at any rate, grass fires.

Greater interest, however, attaches to the leaves, which show a considerable variation, the different species exhibiting an almost complete range from simple to highly compound leaves. The possibility of arranging the species in a series showing increasing leaf division has already been indicated in the case of those species with palmatifid, but not compound, leaves. This series may be continued in a way which shows that the tendency to leaf division has not stopped short at the production of compound leaves, but in several species has resulted in the further division of the leaflets themselves.

Taking first of all the *Eucussonia* group, we have four species with palmatifid, but not compound, leaves. One of these is the curiously distributed *C. natalensis;* the other three are all tropical species. In all of them the leaves are fairly deeply lobed, in *C. arborea* so much so that the leaf is nearly compound. In *C. laciniata* the lobes are themselves deeply divided.

Next, we have a group of species with palmate leaves, the separate leaflets being either sessile or very shortly petiolate, and with entire or serrate margins. In this group are *C. kirkii*—which we have already noticed comes very close to *C. arborea*—*C. barteri, C. vantsilana, C. racemosa*. These, with the exception of the two last, which are Madagascan, are tropical African species. The next group only differs in that the leaflets, still with entire or serrate margins, are more or less long-petioled. *C. holstii, C. microstachys*, and *C. angolensis* are the species forming this group. In the last-mentioned species the following description in the "Flora of Tropical Africa" seems to indicate a tendency towards division of the leaflets themselves, viz.:—"Leaflets serrate, about five inches long, on stalks one and a half to three inches long, which bear at or near the tip glands, or even teeth, and which in places tend to be winged." These three species are all tropical African.

In a fourth group the leaflets themselves are deeply indented and frequently lobed. In *C. paniculata* the long leaflets are usually pinnatifid throughout their entire length, the division sometimes extending to the midrib and giving a three-lobed leaf. In *C. thyrsiflora* the separate leaflets are usually three-lobed, but there is a good deal of variation. On one leaf there may be simple leaflets and leaflets divided to the mid-rib on one or both sides. Finally, there are two species in which leaf division extends to the formation of secondary leaflets—*C. kraussii* and *C. spicata*.

In these two species, leaf division is carried to such a degree that extraordinarily large and highly compound leaves are produced. At the same time the variation is so great that one finds, even on the same tree, leaves which show almost every stage in the sub-division of the leaflets. Frequently a leaf may be composed of several quite simple leaflets to the outside, while the central leaflets are three-lobed. Further division results in the formation of a somewhat pinnate leaflet with four, five, or six lobes. These lobes often show a tendency to grow out in the form of long wings, when still further division results in their conversion into secondary leaflets. The accompanying series of figures illustrate these various types of leaflets, and it is worth mentioning that all these figures were drawn from leaves of a single tree. It will be noticed that the simple leaflets are all practically sessile, while the compound ones tend to become more and more petiolate with increasing leaf division.

The most extreme type of compound leaf found in this species was one picked from a tree growing in close bush. In this, one of the central leaflets was replaced by what at first sight was taken for a primary leaf. A second glance showed that it was in reality an extraordinarily developed leaflet with a long petiole, bearing quite as many secondary leaflets as an ordinary leaf.

Compounding of the leaf also occurs in the *Neocussonia* group, but not to anything like the same degree as in *Eucussonia*. Of the five species, two have non-compound leaves. In *C. monophylla* the leaves are simple and obovate-oblong; in *C. gerrardi* they are lobed and palmatifid. *C. bojeri* has compound leaves with sessile leaflets. In *C. umbellifera* and *C. myriantha* the leaflets are petiolate, but (in the former at all events) the leaflets are themselves simple with an undulate-serrate or entire margin.

In the leaves of all the South African species it is very noticeable that leaf division is much more pronounced in the central leaflets than in the marginal leaflets. Thus, in *C. spicata* and *C. kraussii* the outer leaflets are frequently simple, the intermediate ones lobed on one or both sides, while the central ones are pinnate and frequently bear secondary leaflets. Similarly, in *C. thyrsiflora* the outer leaflets are usually simple and the inner ones three-lobed. In *C. umbellifera* this is also evident, not in leaflet division, but in the production of leaflet petioles, those of the central leaflets being longer than those of the outer ones.

In the case of *C. spicata*, a young plant has been raised in the greenhouse, and it is interesting to find in this almost every stage in the transition from simple to compound leaves. Growth proceeds very slowly, and during the first six months only two or three leaves are produced, all of which are simple and only slightly lobed. As growth proceeds, these leaves become more and more deeply lobed, and after about a year, the eighth leaf formed is distinctly compound, bearing three entire leaflets. Succeeding leaves rapidly show an increasing number of leaflets, and these in turn soon begin to show further division. The same phenomenon is found to occur on coppice shoots rising from the base of the tree, the lowermost leaves being simple, the next deeply lobed and the sixth or seventh from the base compound, but with few leaflets.

Seedlings of *C. paniculata* were also obtained, and the first few leaves produced were all simple and very similar to the juvenile leaves of *C. spicata*. Growth of these seedlings was not continued, and consequently it is not possible to demonstrate in this case the transition to compound leaves. Leaves from a coppice shoot, however, showed clearly how the compound leaf is formed by lobing of an originally simple leaf.

In the case of *C. thyrsiflora*, the writer was unable to obtain seeds, but was fortunate enough to procure several coppice shoots showing an almost complete transition from simple to compound leaves. These are illustrated together with some typical adult leaflets in Plate III. In these leaves it was found that the increasing morphological differentiation is accompanied by an anatomical differentiation. In the mature leaves there is a well-developed hypoderm, two layers of cells thick. In the simple, juvenile leaves this hypoderm is only

one-layered and is only locally developed. In the first compound leaves with only two or three leaflets, the hypoderm is still only one-layered, but is continuous all over the surface of the leaf.

IV.—Notes on the Probable Evolutionary History of the Genus.

A consideration of the facts regarding leaf-form outlined in the foregoing section seems to point very strongly to the conclusion that the evolution of the genus has been in the direction of increased leaf division. The fact that the species with compound leaves in the adult state show in the seedling stage a definite transition from simple to compound leaves is difficult to interpret except on the hypothesis that leaf division is a character which has been impressed upon these species by their environment, but not sufficiently so to affect the early seedling stages which retain the character of a more primitive, unadapted type. The hypothesis that the juvenile characters of seedlings are those of a primitive, ancestral type has been employed by several botanists in evolutionary studies, and is regarded by Jeffrey (10) as one of the canons of comparative plant anatomy. Providing due caution is exercised in its use, this assumption certainly seems to afford the most reasonable explanation of the occurrence of such juvenile characters. Where, as in the present case, we find several different but closely related species exhibiting similar characteristics in their seedling stages, it is difficult to avoid the conclusion that the juvenile characters are those of the ancestral stock from which the different species have been derived.

If then we accept this hypothesis as a working basis, we are able in this case to use leaf division as a criterion of evolution, and we conclude that species whose leaves remain simple throughout their growth are the most primitive, while those whose leaves become highly compound are the most advanced. In this respect, then, we must regard *C. spicata* and *C. kraussii* as the two most advanced members of the genus, and since the former has sessile flowers, it will probably be considered the more advanced of the two.

Considering now the *Eucussonia* group only, it is clear that it is principally species with compound leaves which occur in South Africa. In this group there are five South African species, of which only one—*C. natalensis*—has simple leaves. In addition to *C. natalensis*, three other species have simple leaves, but these are all tropical. Further, we have already remarked that these species show a progression towards the formation of compound leaves by increasing depth of lobing. The other five tropical species all have compound leaves, two with sessile leaflets and three with more or less long petioled leaflets, but in all the leaflets are entire or serrate-margined, whereas in the South African species the leaflets are themselves deeply lobed or even further divided. These facts suggest very strongly a tropical origin for the genus as a whole, the southern species being derivative. Professor Bews (3) has recently discussed at some length the theory of the origin of our South African flora by southward migration from the tropics, and the facts here recorded appear to provide further evidence for this theory.

In addition to being the most advanced species, *C. spicata* is also the most variable and, probably in consequence of this, the most widely distributed. The extreme variation in leaf characters in this

species has already been commented upon, and also its ability to grow in such different habitats as close bush and open tree-veld. Whether *C. kraussii* exhibits anything like such marked variability is not known, since it is a much less common species. It is very difficult to account for the fact that the two most advanced species, differing only in the presence or absence of pedicels to the flowers, should show such a decided contrast in their distribution, the one extending from the tropics far to the south, the other being restricted to a small area on the Natal coast-belt. The possibility may be suggested that a difference in age may account for the difference in the distribution of these two species, *C. kraussii* having been evolved at a much later date than *C. spicata*, but for the present, this can only be regarded as a speculation.

It may be urged that in the foregoing discussion too much emphasis has been laid upon a single character—leaf division—and that in considering the evolution of a genus, more attention should be given to the floral organs. In this particular genus, the flowers are very uniform and the differences between the species are principally those of the inflorescence and the leaf. It is, of course, possible that in these two respects evolution has not proceeded along parallel lines and that species may be primitive in the characters of the inflorescence and advanced in leaf characters. In reality, however, *C. spicata* appears to be the most advanced species in both respects. The inflorescences in the *Eucussonia* group are either spicate or racemose, and it seems generally agreed that of the two the former is the more advanced type. If this is correct, it is difficult to imagine a more advanced inflorescence in the genus than the spike of *C. spicata*, with its densely aggregated, sessile flowers. Species with simple leaves, however, also possess spikes, e.g. *C. arborea* and *C. natalensis*. Apparently, therefore, species may be primitive as far as their leaf characters are concerned and yet be relatively advanced in the characters of the inflorescence.

In conclusion, attention may once more be drawn to the degree of variability of the different species. In Section I of this memoir, the tentative conclusion is put forward that "species which appear early in the plant succession have a greater degree of variability in their structure and physiological functions than those which appear later." The study of leaf-form in *Cussonia* appears to afford further evidence for this. In Natal, *C. spicata* and *C. paniculata* are both pioneers occurring in open veld, whereas *C. umbellifera* is confined to close bush, and there can be no doubt that the latter is far less variable than the other two.

Summary and Conclusions.

1. A general description of the genus *Cussonia* and dichotomous key to the species, based upon the account in Engler's "Pflanzenfamilien" is given.

2. A detailed account of the distribution and ecology of the various species is given, and it is shown that *C. spicata* is the most widely distributed and that it occurs in two very diverse ecological habitats.

3. A study is made of leaf-form in the various species, which are arranged in order of increasing leaf division, *C. spicata* and *C. kraussii* having the most highly compound leaves.

4. The juvenile leaves of *C. spicata*, *C. paniculata*, and *C. thyrsiflora* are simple and show a gradual transition to the compound adult leaves.

5. It is concluded that leaf division may therefore be used as a criterion of evolution within the genus, and a comparison is made of the distribution of the simple-leaved and compound-leaved species This is considered to be suggestive of a tropical origin for the genus.

6. Both in leaf characters and those of the inflorescence, *C. spicata* is regarded as the most advanced species. It is also the most variable and the most widely distributed.

EXPLANATION OF FIGURES.

Plate I. Juvonile leaves from a young plant of *C. spicata*, showing transition from simple to compound leaves of increasing complexity.

Plate II. Typical leaflets of *C. spicata*, showing variation in leaf form; 1, 2, 3 from one leaf, 4, 5, 6 from another leaf, of the same tree.

Plate III. 1 and 2: Juvenile leaves of *C. thyrsiflora*.
3: Young coppice shoot of *C. thyrsiflora*, bearing simple leaves.
4, 5, 6: Typical leaflets of mature leaves of *C. thyrsiflora*.

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PLATE I.

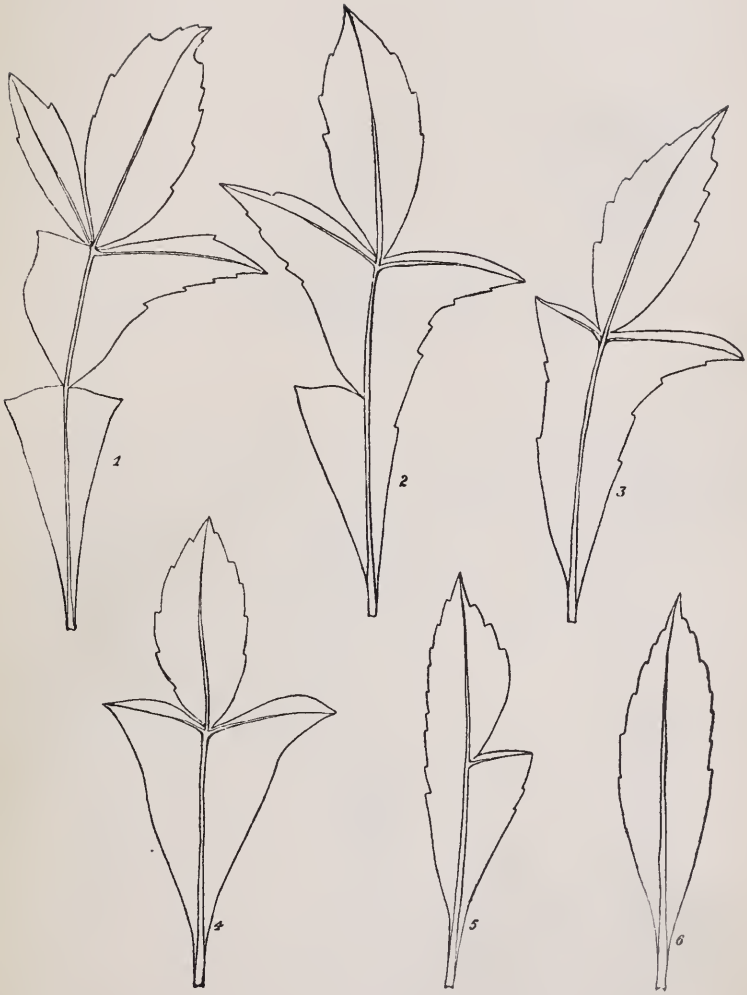

PLATE II.

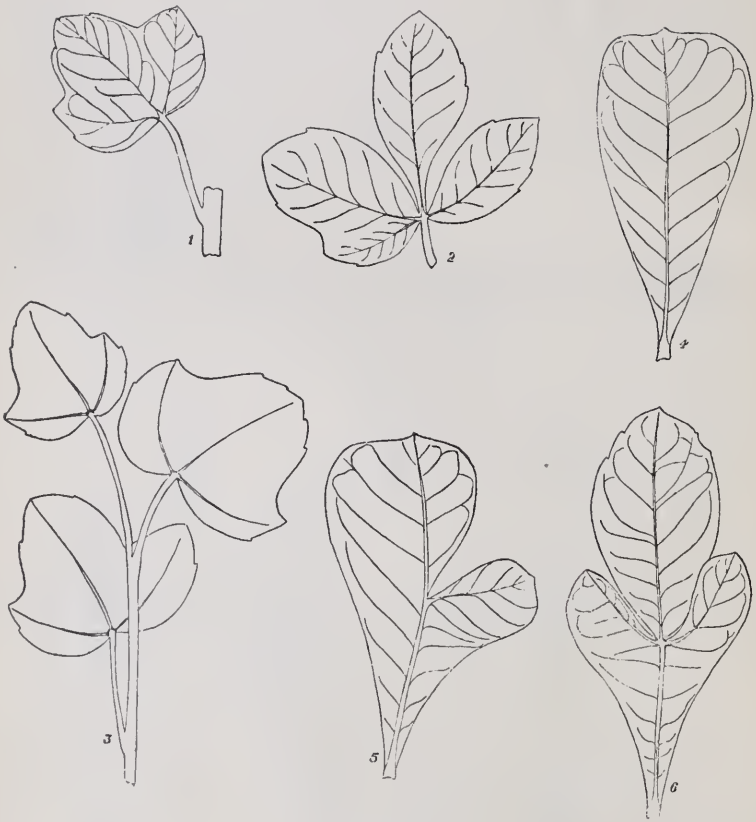

PLATE III.

BOTANICAL SURVEY OF SOUTH AFRICA

MEMOIR No. 6

A PRELIMINARY CHECK LIST

OF

PLANT DISEASES

OCCURRING IN SOUTH AFRICA

COMPILED BY

E. M. DOIDGE, M.A., D.Sc.

To be had from the Librarian, Agricultural Department, Union Buildings

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A PRELIMINARY CHECK LIST

OF

PLANT DISEASES OCCURRING IN SOUTH AFRICA.

COMPILED BY

ETHEL M. DOIDGE.

At a conference of botanists held in Pretoria during March, 1923, it was decided that a plant-disease survey of the Union should be undertaken, and that a preliminary check list should be compiled from existing records to act as a basis for such a survey. The present list is the outcome of that resolution; it has been compiled from the records of the Division of Botany and of the various Agricultural Schools. In many cases there is nothing to indicate who has been responsible for the determinations, so that it is impossible to take any responsibility for the accuracy of some of the records.

The list is of necessity far from complete, and must only be regarded, as was intended, as a basis for future work in plant-disease survey.

The recent edition of Bailey's "Encyclopedia of Horticulture" has been used as a basis of nomenclature for the hosts.

ALMOND (*Prunus communis*, Fritsch).

Anthracnose on green fruit (*Gloeosporium amygdalinum*, Brig.).
Groot Drakenstein, 1915.

Crown Gall (*Bacterium tumefaciens* Smith and Towns).
Pretoria, 1915.

Gummosis (*cause unknown*).
Elgin, C.P., 1922.

Kernel Rot (*cause unknown*).
Koelenhof, C.P., 1922.

Rust (*Puccinia pruni-spinosae* Fritsch).
Potgietersrust, Transvaal, 1923.

Scab (*Cladosporium carpophilum* Thum).
On twigs, Grahamstown, 1917.

Shot Hole (*Cercospora circumcissa* Sacc.).
Klerksdorp, Transvaal, 1910; Wellington, C.P., 1911.

ALOE (*Aloe* spp.).

Leaf Blotch [*Placoasterella Rehmii* (P. Henn.) Th. and Syd.].

Cape Province: Ripplemead, 1915; Montagu, 1915; Transkei, 1913.

Natal: Maritzburg, 1911, 1923.

Rust (*Uromyces aloes* Cke.).

Cape Province: Port Elizabeth, 1912; East London, 1916.

Natal: Mooi River, 1891; Durban, 1922.

Transvaal: Potgietersrust, 1906; Johannesburg, 1922; Pretoria, 1907, 1923.

Orange Free State: Bloemfontein, 1920.

Scab (*Montagnella maxima* Mass).

Cape Province: Port Elizabeth, 1911, 1912; Graaff-Reinet, 1912; Uitenhage, 1912.

Transvaal: Potgietersrust, 1922.

AMATUNGULA (*Carissa grandiflora* D.C.).

Black Spot (*Macowaniella congesta* Doidge).

On leaves and stems. Natal: Durban, 1911; Krantzkloof, 1915; Isipingo, 1918.

Damping Off in seedlings (*Rhizoctonia* sp.).

In greenhouse. Pretoria, 1923.

APPLE (*Pyrus malus* L.).

Apple Cracking Disease (*Coniothecium chomatosporum* Corda).

Occurs commonly in all four Provinces.

Bitter Pit.

Widely distributed; occurring chiefly on young trees.

Bitter Rot [*Glomerella cingulata* (Stoneman) Sp. and Von Schr.].

Cape Province: Clumber, Bathurst District, 1912, 1916; Humansdorp District, 1910; Grahamstown District, 1914; Trapp's Valley, 1911, 1914; Langkloof Valley, 1914; Manley Flats, 1914; Umtata, 1916; prevalent in Humansdorp District, Bathurst District, Komgha, and Kingwilliamstown, 1917; Hankey, 1919.

Transvaal: Haenertsburg, 1911; Johannesburg, 1921.

Natal: Maritzburg, 1915.

Black Rot Canker (*Physalospora Cydoniae* Arnaud).

Cape Province: East London, 1912; Maclear, 1912; Simondium, 1920; French Hoek, 1916; Uniondale, 1912; Groot Drakenstein, 1915; Grahamstown, 1917; Elsenburg, 1916; Stellenbosch, 1922.

Natal: Buccleuch, 1917; Nottingham Road, 1917; Maritzburg, 1916.

Transvaal: Pietersburg, 1913; Pienaars Poort, 1917; Pretoria, 1911, 1912; Vereeniging, 1921.

Blue Mold [*Penicillium expansum* (Lk.), emend Thom].

Causing rot in apples in cold storage. Johannesburg, 1918.

Brown Rot [*Sclerotinia fructigena* (Pers) Schrot].

Twigs affected. Johannesburg, 1917.

Canker (*Botryosphaeria mali* Putt.).

Transvaal: Vereeniging, 1919, in Versfeld, Chenimurie, and White Winter Pearmain; Lichtenburg, 1919.

Cape Province: Trapp's Valley, 1920.

Canker (*Nectria ditissima* Tul.).

Orange Free State: Parys, 1920.

Natal: Krantzkloof, 1916.

Transvaal: Zoutpansberg, 1913.

Chlorosis.

Transvaal: Balfour, 1911; Roodepoort, 1914; Germiston, 1915; Christiana, 1919; Potchefstroom, 1920; Louis Trichardt, 1921.

Cape Province: Grahamstown, 1913; George, 1917; Graaff-Reinet, 1923.

Orange Free State: Parys, 1910.

Crown Gall (*Bacterium tumefaciens* Smith and Towns).

Widely distributed in all four Provinces.

Die Back [*Valsa leucostoma* (Pers) Sacc.].

Cape Province: Great Brak River, 1912; Barkly West, 1921; Constantia, 1920, 1922; Maclear, 1912.

Orange Free State: Bethulie, 1913; Swinburne, 1914; Senekal, 1915; Harrismith, 1914; Parys, 1921.

Natal: Muden, 1914.

Transvaal: Meyerton, 1919; Pietersburg, 1913.

Fly Speck [*Leptothyrium pomi* (Mont. and Fr.) Sacc.].

Idutywa, Transkei, 1923.

Hairy Root. See **Crown Gall.**

Leaf Mottling (*cause unknown*).

Cape Province: Constantia, 1922; Elgin, 1923; Bonnievale, 1923; Simondium, 1923.

Pink Disease (*Corticium laetum* Karst.).

Wound parasite: becomes an active parasite under moist conditions; development favoured by misty rain.

Hilton Road, Natal, 1918, 1921.

Pink Rot [*Cephalotheeium roseum* (Fr.) Corda].

Attacking apples affected with scab, common on fruit exposed for sale in Durban, 1908. Also subsequent to attacks of bitter rot, 1919.

Powdery Mildew [*Podosphaera leucotricha* (E. and E.) Salm.].

Very common and widely distributed in all four Provinces.

Scab [*Venturia inaequalis* (Cke.) Wint.].

Cape Province: Villiersdorp, 1919; Trapp's Valley, 1920; French Hoek, 1918, 1919; Stellenbosch, 1919, 1921, 1923; Grahamstown, 1917; Kingwilliamstown, 1911; Trapp's Valley, 1920; Somerset West, 1920; Somerset East, 1923.

Transvaal: Haenertsburg, 1913, 1914, 1918; Louis Trichardt, 1922.

Root Rot (*Rosellinia* sp.).

Killing young trees, Gravenstein and Jonathan varieties, planted in heavy soil, Rustenburg District, Transvaal, 1906.

Killing nursery stock, Maritzburg, Natal, 1922.

Sclerotial Disease (*Sclerotium* sp.).

Natal: Prevalent in nurseries in neighbourhood of Maritzburg, 1918, 1923, destroying Northern Spy Stock, also at Braecroft, 1918; and New Hanover, 1919.

Transvaal: Godwan River, 1921; Duivelskloof, Magaliesberg, 1922; attacking four-year-old Delicious Apple planted in wet heavy soil.

Sooty Blotch [*Leptothyrium pomi* (Mont. and Fr.) Sacc.].

Natal: Dennybrook, 1923.

Sun Scald.

Cape Province: Trapp's Valley, 1911; East London, 1913; Manley Flats, 1914; Bonnievale, 1923.

Transvaal: Rosslyn Siding, 1921.

Superficial Bark Canker (*Myxosporium corticolum* Edgerton).

Natal: Maritzburg, 1913, causing die back.

Transvaal: Vereeniging, 1919.

Trunk Rot (*Schizophyllum commune* Fr.).

Cape Province: Wynberg, 1922; Stellenbosch, 1918.

Transvaal: Vereeniging, 1922.

Twig Blight (*Phoma mali* Schultz and Sacc.).

Natal: Cedara, 1921, attacking wood of young trees.

Transvaal: Barberton, 1911; Pietersburg, 1913.

Twig Blister.

This is possibly due to frost injury. The twigs show numerous small raised blisters which correspond to small brown lesions in the cortical tissues. It is common where frosty mornings are followed by a hot midday sun; certain varieties, e.g. Rome Beauty, Ohenimuri, and White Winter Pearmain, are most susceptible.

Transvaal: Meyerton, 1919; Grasmere, 1920.

Water Core, Glassiness.

This is also closely connected with climatic conditions and often occurs with bitter pit on young trees 5-7 years old. It is more pronounced in some seasons than in others.

Transvaal: Blackhill, 1914; Johannesburg, 1917; Pretoria, 1921; Carolina, 1922.

Natal: Donnybrook, 1923.

Orange Free State: Bloemfontein, 1915.

Rhodesia.

APRICOT (*Prunus armeniaca* L.).

Canker (*Calosphaeria princeps* Tvl.).

Orange Free State: Swinburne, 1912.

Natal: Glenisla, 1912; Dundee, 1914.

Chlorosis.

Cape Province: Graaff-Reinet, 1923; Wellington, 1922; Bonnievale, 1923.

Crown Gall (*Bacterium tumefaciens* Smith and Towns).

Cape Province: Maclear, 1912; Swellendam, 1921; Longhope, 1923; Grahamstown, 1921; Paarl, 1921.

Transvaal: Kroondal, Rustenburg District, 1914; Pretoria, 1921; Wakkerstroom, 1911.

Orange Free State: Zastron, 1912.

Die Back [*Valsa leucostoma* (Pers) Sacc.].

Orange Free State: Swinburne, 1912.

Freckle (*Cladosporium carpophilum* Thun.).

Cape Province: Paarl, 1913; Wellington, 1919.

Transvaal: Johannesburg, 1910; Pretoria, 1910; Carolina, 1907; Pan, 1920; Bethal, 1922.

Natal: Besters, 1920.

Orange Free State: Harrismith, 1919.

Rust (*Puccinia pruni-spinosae* Pers).

Cape Province: Wellington, 1911, 1913, 1919, 1922; Paarl, 1912; Glenlyon, 1915; Graaff-Reinet, 1912; Little Brak River, 1923.

Shot Hole (*Bacterium pruni* Erw. Sm.).

Cape Province: Lovedale, 1917.

Shot Hole (*Cercospora circumcissa* Sacc.).

Transvaal: Machadadorp, 1909; Eureka, 1909.

Shot Hole [*Phyllosticta prunicola* (Op.) Sacc.].

Basutoland, 1911.

Silver Leaf (*Stereum purpureum* Fr.)

Cape Province: Rondebosch, 1920, 1921; Wynberg, 1921; Lategan, 1922; Simondium, 1922.

Sour Sap.

Cape Province: Lategan, 1922.

Trunk Rot (*Polyporus proteus*).

Cape Province: Wellington, 1921.

Trunk Rot (*Schizophyllum commune* Fr.).

Cape Province: Wellington, 1919-1920.

Transvaal: Potgietersrust, 1921.

Twig Blister (*Phoma* sp.).

Transvaal: Pretoria, 1921.

ARAUCARIA (*Araucaria* spp.).

Fusarium sp.

Zululand, 1922.

Pestalozzia funerea Desm.

Zululand, 1922.

ARTICHOKE (*Helianthus tuberosus* L.).

Tuber and **Storage Rot** (? *Acremonium* sp.).

Cape Province: Rosebank, 1922.

Transvaal: New Agatha, 1923.

ARUM (*Zantedeschia* spp.).

Leaf Spot (*Septoria ari* Desm.).

Cape Province: Wellington, 1910

Mildew (*Oidium* sp.).

Transvaal: Pretoria, 1909; Barberton, 1912.

Rust (*Aecidium ari* Desm.).

Natal: Malvern, 1910-1911.

ASPARAGUS (*Asparagus officinalis* L.).

Wilt (*Fusarium* sp.).

Cape Province: Kimberley, 1911; shoots withering as soon as they push through the ground.

AVOCADO (*Persea americana* Mill).

Anthracnose (*Gloeosporium* sp.).

Transvaal: Barberton, 1920; on fruit.

Canker (*Physalospora Perseae* Doidge).

Transvaal: Louis Trichardt, 1921; causing serious stem cankers.

BANANA (*Musa sapientum* L.).

Anthracnose (*Gloeosporium musarum* Cke. and Mass.).

Natal: Umhlali, 1923; Winklespruit, 1919.

Portuguese East Africa: Lourenco Marques, 1920.

BARBERTON DAISY (*Gerbera Jamesonii* Hook).

Leaf Spot (*Septoria gerberae* Syd.).

Natal: Maritzburg, 1917.

Transvaal: Pretoria, 1906, 1916; Barberton, 1912.

White Rust (*Cystopus tragopogonis* Pers).

Transvaal: Barberton, 1911; Johannesburg, 1917; Pretoria, 1918.

BARLEY (*Hordeum* spp.).

Black Rust (*Puccinia graminis* Pers).

Transvaal: Pretoria, 1906; Potchefstroom, 1910.

Cape Province: Middelburg, 1907; Elsenburg, 1920.

Covered Smut [*Ustilago Hordei* (Pers) Kell. et Sw.].
Cape Province: Elsenburg, Albany, Constantia, 1922; Kimberley, 1913.
Transvaal: Carolina, 1913; Johannesburg, 1906; Pretoria, 1905; Standerton, 1907.
Orange Free State: Without locality, 1907.

Leaf Blotch (*Helminthosporium* sp.).
Cape Province: Elgin, 1914; Grootfontein, 1923.
Transvaal: Pretoria, 1909.

Loose Smut [*Ustilago nuda* (Jens.) Kell. en Sw.].
Cape Province: Elsenburg.

Mildew (*Erysiphe graminis* D.C.).
Cape Province: Grahamstown, 1920.
Transvaal: Pretoria, 1907; Wonderboom, 1906.

BEANS.

BROAD BEAN (*Vicia Faba* L.).

Blight (*Alternaria* sp.).
Natal: Cedara, 1923, very severe.

Rust [*Uromyces Fabae* (Pers) De Bary].
Transvaal: Wolmaransstad, 1918; Pretoria, 1911.
Cape Province: Somerset West, 1922; Port Elizabeth, 1916; Wellington, 1906; Grahamstown, 1907; Butterworth, 1914.
Natal: Impendhle, 1922; Cedara, very severe, 1923.

CHINESE MUNG (*Phaseolus radiatus* L.).

Bacterial Blight (*Bacterium Phaseoli* Erw. Sm.).
Natal: Cedara, 1922.

Leaf Spot (*Ascochyta pisi* Lib.).
Natal: Cedara, 1922, practically killed all the plants in the experimental plot.

FRENCH BEAN, RUNNER BEAN (*Phaseolus vulgaris* L. and P. *multiflorus*, Willd.).

Anthracnose [*Colletotrichum lindemuthianum* (Sacc. and Mayn) Bd.].
Cape Province: Oudtshoorn, 1917.
Transvaal: Middelburg, 1915; Eureka, 1919; Barberton, 1906; Pretoria, 1909; Nelspruit, 1917.
Natal: Cedara, 1923.

Bacterial Blight (*Bacterium Phaseoli* Erw. Sm.).

Cape Province: Macleantown, 1922; Somerset East, 1922; Kimberley, 1922.

Transvaal: Amsterdam, 1918; Pokwani, 1918; Pretoria, 1921; Potgietersrust, 1921; Premier Mine, 1922; Pietersburg, 1920.

Natal: Cedara, 1922.

Leaf Blotch (*Cercospora cruenta* Sacc.).

Natal: Cedara, 1922, severe on a number of varieties; Winklespruit, 1912.

Cape Province: Oudtshoorn, 1917.

Transvaal: Barberton, 1916.

Leaf Scorch (*Isariopsis griseola* Sacc.).

Transvaal: Pretoria, 1918.

Leaf Scorch (*Phyllosticta phaseolina* Sacc.).

Transvaal: Pretoria, 1920.

Leaf Spot (*Macrosporium phaseoli* Fautr.).

Cape Province: Without locality, 1907; Bathurst, 1922.

Pod Blight (*Phoma subcircinata* Ell and Ev.).

Zululand: Eshowe, 1914.

Root Parasite (*Melasma orobauchoides*).

Transvaal, Nylstroom, 1920.

Root Rot (*Fusarium* sp.).

Cape Province: Somerset Strand, 1919; Uitenhage.

Rust [*Uromyces appendiculatus* (Pers) Lev.].

Transvaal: Pretoria, 1914; Nelspruit, 1914; Amsterdam, 1917; Zoutpansberg, 1909; Daspoort, 1909; Wonderboom, 1911.

Cape Province: Wellington, 1921; Hankey, 1919; Kentani, 1914-1915.

Natal: Cedara, 1922, several varieties badly affected.

HYACINTH BEAN (*Dolichos lablab* L.).

Leaf Spot (*Ascochyta pisi* Lib.).

Natal: Cedara, 1922-1923.

LIMA BEAN (*Phaseolus lunatus* L.).

Leaf Spot (*Ascochyta pisi* Lib.).

Natal: Cedara, 1922.

VELVET BEAN (*Mucuna utilis*).

Leaf Spot (*Phyllosticta* sp.).
Transvaal: Rustenburg, 1906.
Rhodesia: Salisbury, 1920.

Rust [*Uromyces appendiculatus* (Pers) Lev.].
Rhodesia: Without locality, 1921.

KAFFIR BEAN. See **COW PEA.**

KAFFIR GROUND BEAN (*Voandzeia subterranea* Thouars).

Mildew (*Erysiphe polygoni* D.C., oidial stage).
Natal: Cedara, 1923.
Swaziland: 1916.

SOY BEAN (*Glycine hispida*).

Downy Mildew (*Peronospora trifoliorum* De Bary).
Natal: Cedara, 1923, slight attack on most varieties.

Leaf Blight (*Alternaria* sp.).
Natal: Cedara, 1922-1923, fairly severe on American Flat Brown; other varieties slightly attacked.

Leaf Spot (*Phoma* sp.).
Natal: Cedara, 1923.

BEET, SUGAR BEET, SPINACH BEET (*Beta vulgaris* L.).

Leaf Spot (*Cercospora beticola* Sacc.).
Natal: Maritzburg, 1923; Cedara, 1911, 1922.

Rust [*Uromyces Betae* (Pers) Kuhn].

BRINJAL. See **EGG PLANT.**

BUCHU (*Barosma* spp.).

Root Rot (*cause unknown*).
Cape Province: Piquetberg, 1917, 1921.

CABBAGE and **CAULIFLOWER** (*Brassica oleracea* L.).

Bacterial Spot (*Bacterium maculicolum* McC.).

Transvaal: Pretoria, 1920, 1923; Rustenburg, 1922; Godwan River, 1921.

Cape Province: Wellington, 1916.

Black Mold [*Alternaria brassicae* (Bek.) Sacc.].

Transvaal: Godwan River, 1921.

Black Rot [*Bacterium campestre* (Pam) Erw. Sm.].

Transvaal: Potchefstroom, 1922; Pan, 1921; Pretoria, 1922; Piet Retief, 1912; Sabie, 1915; Sheba, 1917; Ermelo, 1918; Heidelberg, 1923; Wolmaransstad, 1914.

Natal: Ixopo, 1921; Riet Vlei, 1916; Cedara, 1923; Merrivale, 1923.

Cape Province: Balfour, 1915; East London, 1923.

Club Root, Dik Voet, Finger and Toe (*Plasmodiophora brassicae* Wor.).

Cape Province: Brackenfell, 1913, occurred right through dunes, and at Kuils River, Port Elizabeth.

Orange Free State: Bothaville, 1918.

Downy Mildew (*Peronospora parasitica* De Bary).

Natal: Krantzkloof, 1914.

Foot Rot (*Phoma brassicae* Thum).

Transvaal: Piet Retief, 1920.

Natal: Maritzburg, 1913; Mooi River, 1919.

CALABASH (*Lagenaria vulgaris* Ser.).

Mosaic Disease.

Natal: Verulam, 1923.

CAPE GOOSEBERRY (*Physalis peruviana* L.).

Leaf Spot [*Entyloma Physalidis* (Kalch and Cke.) Wint].

Cape Province: Grahamstown, 1907; Wellington, 1906.

Transvaal: Pretoria, 1907; Barberton, 1907.

CARNATION (*Dianthus caryophyllus* L.).

Fairy Ring Disease [*Heterosporium echinulatum* (Berk), Cke.].

Natal: Without locality, 1910.

Leaf Spot (*Septoria Dianthi* Desm.).

Transvaal: Johannesburg, 1910, 1917; Vereeniging, 1911; Pietersburg, 1921.

Natal: Nelsrust, 1917.

Leaf Spot [*Ascochyta Dianthi* (Alb. and Schw.) Berk].

Cape Province: Queenstown, 1922.

Leaf Spot (*Macrosporium nobile* Vize).

Transvaal: Pretoria, 1912.

Rust [*Uromyces caryophyllinus* (Schrank) Wint.].

Transvaal: Johannesburg, 1906, 1911, 1913, 1914; Pietersburg, 1912; Pretoria, 1911, 1913.

Natal: Pinetown, 1914.

Cape Province: East London, 1915; Queenstown, 1922; Capetown, 1922; Fisch Hoek, 1923.

Portuguese East Africa: Lourenço Marques, 1912, 1914.

Wilt or **Crown Rot** (*Fusarium* sp.).

Natal: Krantzkloof, 1913; Gillitts, 1911; Durban, 1911; Maritzburg, 1918; Fields Hill, 1911; Sarnia, 1920.

Orange Free State: Bloemfontein, 1911.

Transvaal: Johannesburg, 1913; Louis Trichardt, 1916, 1920; Middelburg, 1916; Heidelberg, 1922.

Cape Province: Great Brak River, 1919; Barkly West, 1921; Graaff-Reinet, 1922.

Portuguese East Africa: Lourenco Marques, 1913.

CARROT (*Daucus carota* L.).

Blight [*Alternaria brassicae* (Berk) Sacc.].

Natal: Cedara, 1922, severe during moist condition.

Root Disease (*Phoma sanguinolenta* Rostr.).

Natal: Cedara, 1911.

CASTOR OIL (*Ricinus communis* L.).

Rust [*Melampsorella Ricini* (Biv.) De Toni].

Transvaal: Pretoria, 1906, 1921; Zoutpansberg, 1906.

Cape Province: Grahamstown, 1908.

Southern Rhodesia: Without locality, 1917.

CAULIFLOWER. See **CABBAGE.**

CELERY (*Apium graveolens* L.).

Leaf Spot (*Septoria Petroseleni* Desm., var. *Apii* Br. et Cav.).

Natal: Bergville, 1923.

Transvaal: Pretoria, 1913, 1917.

CHERRY (*Prunus* spp.)

Brown Rot [*Sclerotinia fructigena* (Pers) Schroet].

Cape Province: Kubusie, 1918; Kokstad, 1913.

Crown Gall (*Bacterium tumefaciens* Sm. and Towns).

Transvaal: Wakkerstroom, 1911.

Orange Free State: Reddersburg, 1920.

Leaf Spot (*Ascochyta* sp.).

Transvaal: Belfast, 1920.

Leaf Spot (*Cylindrosporium Padi* Karst.).

Transvaal: Belfast, 1915.

Trunk Rot (*Schizophyllum commune* Fr.).

Cape Province: Koelenhof, 1921.

CHILLI (*Capsicum* sp.).

Sclerotial Disease (*Sclerotium Rolfsii* Sacc.).

Transvaal: Nelspruit, 1922.

CHRYSANTHEMUM (*Chrysanthemum* spp.)

Leaf Blight (*Cylindrosporium chrysanthemi* Ell. and Desm.).

Natal: Maritzburg, 1916.

Leaf Spot (*Septoria chrysanthemi* Cav.).

Natal: Maritzburg, 1916.

Rust (*Puccinia chrysanthemi* Roze).

Transvaal: Johannesburg, 1905; Barberton, 1905; Maraisburg, 1917; Newclare, 1919.

Cape Province: Port Elizabeth, 1912; Kowie, 1916; Mossel Bay, 1917.

COFFEE (*Coffea arabica* L.).

Rust (*Hemileia vastatrix* Berk and Br.).

Transvaal: Zoutpansberg District, very severe in 1903; New Agatha, 1907.

Natal: Verulam, 1914; Maritzburg, 1918.

Rhodesia: Without locality, 1914.

COSMOS (*Cosmos bipinnatus* Cav.).

Mildew [*Sphaerotheca humuli* (D.C.) Burr, var. *fuliginea*].

Transvaal: Pretoria, 1911.

COTTON (*Gossypium* spp.).

Angular Leaf Spot (*Bacterium malvacearum* Erw. Sm.).

Transvaal: Warmbaths, 1917; Wolhuterskop, 1921; Pietersburg, 1922; Haakdoorn, 1923; Rustenburg, 1911, 1919, 1922; Pretoria, 1907; Bontfontein, 1923.

Swaziland: Without locality, 1919.

Natal: Without locality, 1915; Maritzburg, 1923; Equeefa, 1911.

Anthracnose [*Glomerella Gossypii* (South) Edg.].

Transvaal: Graskop, 1919; Pretoria, 1904.

Natal: Without locality, 1915; Maritzburg, 1910; Inyoni, Zululand, 1920.

Black Rust (*Macrosporium nigricantium* Atk.).

Cape Province: East London, 1911.

Natal: Without locality, 1911; Richmond, 1911.

Portuguese East Africa: Without locality, 1923.

Boll Rot (*Fusarium* sp.).

Zululand: Without locality, 1923.

False Mildew (*Ramularia areola* Atk.).

Swaziland: Without locality, 1908.

Wilt [*Neocosmospora vasinfecta* (Atk.) Erw. Sm.].

Cape Province: East London, 1915.

Natal: Durban, 1918; Weenen, 1917.

Transvaal: Komatipoort, 1921; Godwan River, 1921; Spelonken, 1923.

Portuguese East Africa: Without locality, 1909.

COW PEA (*Vigna catjang* Walp).

Anthracnose [? *Glomerella lindemuthianum* (Sacc.) Magn.].

Natal: Cedara, 1922, severe in field and experimental plots.

Bacterial Leaf Spot (? *cause*).

Transvaal: Kempton Park, 1920; Potchefstroom, 1912.

Orange Free State: Westleigh, 1922.

Natal: Cedara, 1922.

Leaf Blotch (*Cercospora cruenta*, Sacc.).

Natal: Maritzburg, 1923.

Leaf Spot (*Ascochyta pisi* Lib.).

Natal: Cedara, 1922.

Leaf Spot (*Phyllosticta* sp.).

Natal: Creighton, 1917.

Transvaal: Wonderboom, 1914.

Mildew (*Erysiphe Polygoni* D.C.).

Natal: Cedara, 1922.

Root and **Pod Rot** (*Corticium vagum* B. and L., var. *Solani* Burt.).

Natal: Cedara, 1922.

Rust [*Uromyces appendiculatus* (Pers) Lk.].

Natal: Cedara, 1922, appeared late in season, damage slight.

Sclerotial Disease (*Sclerotium* sp.).

Natal: New Hanover, 1920.

CUCUMBER (*Cucumis sativus* L.).

Wilt (? *Bacillus tracheiphilus* Erw. Sm.).

Transvaal: Kliptown, 1922. Vessels choked with bacteria, but identity of organism has not been established by culture.

Downy Mildew (*Peronospora cubensis* Berk and Curt.).

Transvaal: Barberton, 1909.

Cape Province: East London, 1923.

Powdery Mildew (*Erysiphe cichoracearum* D.C.).

Transvaal: Elim, 1921; Nelspruit, 1906, 1919; Pretoria, 1914; Barberton, 1914; Hartebeestrivier Mond, 1914.

Cape Province: Port Alfred, 1920; Capetown, 1916.

CYPRESS (*Cupressus* spp.).

Macrosporium sp.

Transvaal: Piet Retief, 1923.

Pestalozzia funerea Desm.

Transvaal: Irene, 1912; Belfast, 1918; Piet Retief, 1923.

Phoma abietina Don.

Transvaal: Belfast, 1916.

Polyporus gilvus Schw.

Transvaal: Graskop, 1921.

Xylaria sp.

Transvaal: Ermelo, 1912.

CUSTARD APPLE (*Anona reticulata* L.).

Collar Rot (*? cause*).

Cape Province: Little Brak River, 1923.

EGG PLANT (*Solanum melongena* L., var. *esculentum*, Nees).

Wilt (*Bacterium solanacearum* Erw. Sm.).

Transvaal: Nelspruit, 1922.

EUCALYPTUS (*Eucalyptus* spp.).

Armillaria mellea Vahl.

Cape Province: Eastern District, 1915.

Cytospora Australiae Speg.

Transvaal: Pretoria, 1919.

Damping Off (*? cause*).

Cape Province: George, 1921.

Fomes annosus Fr.

Cape Province: Pirie, 1915.

Harknessia uromycoides Speg.

Transvaal: Irene, 1912.

Leaf Spot (*? Pseudolembosia* sp.).

Cape Province: Jessievale, 1923.

Natal: Rosetta, 1920.

Stereum hirsutum (Willd.) Fr.

Cape Province: Eastern District, 1915.

Transvaal: Cliffendale, near Roodepoort, 1920.

FIG (*Ficus carica* L.).

Die Back (*Phoma* sp.).

Transvaal: Randfontein, 1920; Johannesburg, 1921.

Fruit Spot (*? cause*).

Cape Province: Stellenbosch, 1921; St. James, 1922, causes premature dropping.

Leaf Blotch [*Cercospora bolleana* (Thuem) Speg.].

Transvaal: Pretoria, 1906; Naboomspruit, 1921.

Cape Province: Without locality, 1906.

Rust (*Uredo Fici* Cast.).

Cape Province: Grahamstown, 1907; Eastern District, 1911.

FOXGLOVE (*Digitalis* sp.).

Stem Rot (*Phoma* sp.).

Natal: Maritzburg, 1919.

GERANIUM (*Pelargonium* spp.).

Dodder (*Cuscuta arvensis*).

Transvaal: Klerksdorp, 1921.

Leaf Spot (*Septoria Pelargonii* Syd.).

Transvaal: Barberton, 1906.

Cape Province: Wynberg, 1915.

Rust (*Puccinia granularis* Kalch and Cke.).

Transvaal: Johannesburg, 1908; Krugersdorp, 1907; Pretoria, 1915; Warmbaths, 1919.

Cape Province: Capetown, 1907, 1915; Cradock, 1914; Sea Point, 1920.

Natal: Maritzburg, 1913.

Rust [*Uromyces Geranii* (D.C.) Otth. and Wartm.].

Transvaal: Johannesburg, 1911; Nylstroom, 1912; Warmbaths, 1919; Pretoria, 1911.

Cape Province: Kenilworth, 1913.

GRANADILLA (*Passiflora quadrangularis* L.).

Leaf Spot (*Macrosporium* sp.).

Transvaal: Johannesburg, 1918.

GRAPE (*Vitis* spp.).

Anthracnose (*Gloeosporium ampelophagum* Sacc.).

Occurs commonly throughout the four Provinces, often causing considerable injury.

Black Rot (*Guignardia Bidwellii* Vi. et Rav.).

Natal: Maritzburg, 1911.

This single occurrence of black rot was dealt with by quarantine measures, and no further spread of the disease has been recorded.

Blister Blight (*Exobasidium vitis* Prill.).

Transvaal: Pretoria, 1919.

Court Noue.

Cape Province: Paarl, 1922.

Crown Gall (*Bacterium tumefaciens* Sm. and Towns).

Transvaal: Pretoria, 1918; Johannesburg, 1922.

Cape Province: Constantia, 1914, 1921; Wynberg, 1922; Elsenburg.

Downy Mildew [*Plasmopara viticola* (B. and C.), Berl and De Toni].

Cape Province: Grahamstown, 1907; Uitenhage, 1907; East Griqualand, 1917.

Natal: Zululand, 1912.

Grey Mold (*Botrytis cinerea* Pers).

Cape Province: Elsenburg, 1919; Camps Bay, 1920; Stellenbosch, 1922.

Transvaal: Johannesburg, 1911, 1913.

Leaf Blight (*Cercospora viticola* Sacc.).

Transvaal: Rustenburg, 1911; Potchefstroom, 1911; Pretoria, 1909; Marico, 1911; Barberton, 1911; Schoerpoort, 1912; Johannesburg, 1913.

Cape Province: East Griqualand, 1917.

Leaf Blotch (*Macrosporium Vitis* Sorok).

Transvaal: Rustenburg, 1911.

Leaf Spot (*Phyllosticta* sp.).

Cape Province: Cradock, 1921.

Powdery Mildew [*Oidium Tuckeri* Berk (Perithecia not observed)].

Occurs commonly in all the four Provinces.

Root Rot (? *Dematophora necatrix* Hartig).

Rhodesia: Without locality, 1914.

GRAPE FRUIT, SHADDOCK (*Citrus grandis* Osbeck).

Scab or **Verrucosis** (? *Cladosporium citri* Mass so called).

Zululand: Amatikulu, 1921.

Wither Tip (*Colletotrichum gloeosporioides* Penz).

Transvaal: Acornhoek, 1923.

GRASSES.

BABALA GRASS. See **PEARL MILLET.**

BERMUDA GRASS, KWEEK GRASS (*Cynodon Dactylon* Pers).

Balansia sp.

Transvaal: Pretoria, 1918, 1920.

Black Spot [*Phyllachora cynodontis* (Niessl.) Sacc.].

Transvaal: Daspoort, 1903; Groenkloof, 1910; Vereeniging, 1910.

Orange Free State: Bloemfontein, 1917.

Natal: Cedara, 1911.

Physarum cinereum (Batsch) Pers.

Transvaal: Johannesburg, 1921; Pietersburg, 1923.

Physarum vernum Somm.

Transvaal: Daspoort, 1906.

Cape Province: Grahamstown, 1920.

Rust (*Puccinia Cynodontis* De Lac.).

Transvaal: Skinners Court, 1906.

Smut (*Cerebella Cynodontis* Syd.).

Transvaal: Pretoria, 1918.

Cape Province: Kentani, 1912.

Smut (*Ustilago Cynodontis* P. Henn).

Transvaal: Daspoort, 1905; Warmbaths, 1905; Vryburg, 1911; Pretoria, 1913, 1917; Marikana, 1917.

Orange Free State: Bloemfontein, 1915.

Cape Province: Kimberley, 1919.

BUFFEL GRASS (*Pennisetum cenchroides* Rich.).

Smut (*Sorosporium* sp.).

Cape Province: Capetown, 1913.

Smut (*Ustilago Penniseti* Rahb.).

Cape Province: Great Karasburg, 1912-1913.

CANARY GRASS (*Phalaris bulbosa* L.).

Alternaria sp. and *Macrosporium* sp.

Natal: Cedara, 1922, heads fairly severely affected; disease made its appearance soon after the ears were formed.

Ergot (*Claviceps* sp.).

Transvaal: Amsterdam, Ermelo, Pretoria.

Natal: Cedara, 1923; 40 per cent. of heads affected, not noticed in previous years.

COCKSFOOT (*Dactylis glomerata* L.).

Leaf Blight (*Clasterosporium claratum* Lev.).

Transvaal: Pretoria, 1905.

Rust (*Puccinia graminis* Pers).

Transvaal, Pretoria, 1907.

Rhodesia: Without locality, 1911.

DEK GRASS (*Setaria aurea* A.Br., and *S. nigrirostris* Dur and Schinz).

Aegerita Penniseti P. Henn.

Natal: Sandymount, 1917.

Ergot (*Claviceps* sp.).

Transvaal: Garstfontein, Pretoria District, 1915.

Epichloe Zahlbrucknerіana P. Henn.

Transvaal: Groenkloof, Pretoria, 1920.

Fusarium heterosporum Nees.

Transvaal: Garstfontein, Pretoria District, 1915; Carolina, 1907.

Black Spot (*Phyllachora Evansii* Syd.).

Transvaal: Pretoria, 1911; Barberton, 1912; Vereeniging, 1917.

Smut (*Ustilago Evansii* P. Henn).

Transvaal: Zoutpansberg, 1906; Groenkloof, Pretoria District, 1915.

Cape Province: Transkei, 1922.

Natal: Without locality, 1914.

Rhodesia: Salisbury, 1914.

ELEPHANT GRASS. See **NAPIER FODDER.**

FINGER GRASS (*Digitaria eriantha* Steud.).

Ergot (*Claviceps* sp.).

Transvaal: Pienaars River, 1921.

Natal: Maritzburg, 1911.

Rust (*Puccinia Digitariae* Pole Evans).

Natal: Cedara, slight in 1922; severe in 1923.

Smut (*Tolyposporium* sp.).

Natal: Maritzburg, 1911.

FOX TAIL MILLET. See **MANNA.**

GOOSE GRASS (*Eleusine indica* Gaertn.).

Smut (*? cause*).

Transvaal: Vereeniging, 1917.

GUINEA GRASS (*Panicum maximum* Jacq.).

Ergot (*Claviceps* sp.).

Cape Province: Kentani.

Fusarium heterosporum Nees.

Cape Province: Kentani, 1913; Butterworth, 1914.

Natal: Maritzburg, 1914.

Transvaal: Barberton, 1914.

Black Spot [*Phaeodothis stenostoma* (Ell. and Fr.) Th. and Syd.].

Natal: Without locality, 1912.

Black Spot (*Phyllachora heterospora* P. Henn).

Natal: Maritzburg, 1911; Winklespruit, 1911; Durban, 1911; Durban, 1923, causing appreciable amount of leaf injury.

Cape Province: Kentani, 1914-1915.

Smut (*Cerebella Panici* Tracy and Earle).

Cape Province: Kentani, 1913; Butterworth, 1914.

Transvaal: Groenkloof, Pretoria, 1915.

Smut (*Ustilago heterospora* P. Henn and Evans).

Natal: Durban, 1922.

Rhodesia: Salisbury, 1920.

ITALIAN RYE GRASS (*Lolium italicum* R. Br.).

Rust (*Puccinia coronifera* Kleb.).

Natal: Mooi River, 1911.

JOHNSON GRASS (*Sorghum halepense* Stapf).

Anthracnose (*Colletotrichum* sp.).

Transvaal: Groenkloof, 1915.

Leaf Blight (*Helminthosporium* sp.).

Natal: Cedara, 1917.

Downy Mildew [*Sclerospora graminicola* (Sacc.) Schroet].
Transvaal: Pretoria, 1918, 1922.

Smut (*Sorosporium Simii* Pole Evans).
Natal: Maritzburg, 1915, 1917.

KIKUYU GRASS (*Pennisetum clandestinum* Chiov.).

Leaf Blight (*Helminthosporium* sp.).
Natal: Mooi River, 1923.

KWEEK GRASS. See **BERMUDA GRASS.**

LARGE SEEDED PANICUM (*Brachiaria brizantha* Stapf).

Ergot (*Claviceps* sp.).
Cape Province: Transkei, 1922.
Transvaal: Rosehaugh, 1914; Nelspruit, 1917.

Smut (*Cerebella Panici* Tracy and Earle).
Transvaal: Krabbefontein, 1914; Nelspruit, 1917.

MANNA (*Setaria italica*, Beauv.).

Smut (*Ustilago Crameri* Korn).
Transvaal: Standerton, 1912.
Zululand: Fort Louis, 1916.

NAPIER FODDER (*Pennisetum purpureum* Schum and Thom).
Aegerita Penniseti.
Rhodesia: 1921.

NATAL BUFFEL GRASS (*Setaria sulcata* Raddi).

Black Spot (*Phyllachoria Evansii* Syd.).
Transvaal: Barberton, 1903.
Natal: Isipingo, 1918; Bluff, Durban, 1919.

NATAL RED TOP (*Tricholaena rosea* Ness.).

Black Spot (*Phyllachora Tricholaenae* P. Henn).
Natal: Winklespruit, 1913.

Rust (*Diorchidium Tricholaenae* P. Henn).

Transvaal: Barberton, 1903.

Natal: Harden Heights, 1911; Winklespruit, 1911; Amanzimtoti, 1911.

Smut (*Sorosporium* sp.).

Natal: Amanzimtoti, 1911.

OLD LANDS GRASS = SWEET GRASS.

PASPALUM (*Paspalum dilatatum* Poir., *P. virgatum* L., *P. scrobiculatum* L.).

Ergot (*Claviceps Paspali* Stev. and Hall).

Transvaal: Lydenburg, 1919; Thabina, 1920; Piet Retief, 1920; Nylstroom, 1918; Lake Chrissie, 1918; Pan, 1919.

Cape Province: Kokstad, 1920; Komgha, 1921; East London, 1916; Port Elizabeth, 1916; Belville, 1919; Rosebank, 1921; Elsenburg, 1921.

Natal: Cedara, 1920; Maritzburg, 1916; Isipofie, 1918; Tugela Valley, 1920.

Orange Free State: Bloemfontein, 1920; Kestell, 1918.

PEARL MILLET (*Pennisetum spicatum* Korn).

Macrosporium sp.

Orange Free State: Tweespruit, 1911.

Phoma sp.

Orange Free State: Tweespruit, 1911.

Smut (*Tolyposporium Penicillaria* Bref.).

Portuguese East Africa: Umbelusi, 1909.

PERENNIAL RYE GRASS (*Lolium perenne* L.).

Rust (*Puccinia coronata* Corda).

Transvaal: Potchefstroom, 1907.

Rust (*Puccinia dispersa* Eriks. Henn).

Transvaal: Pretoria, 1907.

RESCUE GRASS (*Bromus unioloides* H.B.K.).

Smut (*Ustilago bromivora* Fisch de Waldh).

Transvaal: Amersfoort, 1906; Pretoria, 1907; Wakkerstroom, 1907; Zandspruit, 1907.

Orange Free State: Sterkfontein, 1912.

Cape Province: Rosebank, 1917; Elsenburg.

RHODES GRASS (*Chloris gayana* Kth.).

Rust (*Puccinia Chloridis* Speg.).

Transvaal: Groenkloof, near Pretoria, 1918.

Rhodesia: Bulawayo, 1911.

Smut (*Tolyposporium Chloridis* P. Henn).

Natal: Maritzburg, 1911, 1914; Cramond, 1915; Mid-Illovo, 1916.

ROOI GRASS (*Themeda triandra* Forsk).

Rust (*Puccinia* sp.).

Transvaal: Springbok Flats, 1907; Pretoria District, 1911; Johannesburg, 1908.

Smut (*Sorosporium Holstei* P. Henn).

Transvaal: Rietfontein, Pretoria District, 1915; Onderstepoort: Vryburg, 1916.

SPEAR GRASS (*Heteropogon contortus* L.).

Linochorella striiformis Syd.

Transvaal: Pretoria, 1911.

Rust (*Puccinia versicolor* Diet et Holw.).

Transvaal: Pretoria, 1910.

STAR GRASS (*Cynodon plectostachyum* Pilg.).

Black Spot [*Phyllachora cynodontis* (Sacc.), Messl.].

Natal: Cedara, 1923: fairly severe.

SUDAN GRASS (*Sorghum sudanense* Stapf).

Downy Mildew (*Sclerospora graminicola* Schröt).

Zululand, 1922.

Leaf Blight (*Helminthosporium* sp.).

Natal: Maritzburg, 1916: serious attack ruining crop, 1922; Cedara, 1923: crop a failure, very badly diseased.

Rust (*Puccinia purpurea* Cke.).

Cape Province: Schoombie.

SWEET GRASS (*Chloris virgata* Schwartz).

Rust (*Puccinia Chloridis* Speg.).

Transvaal: Skinners Court, Pretoria, 1906.

SWEET GRASS (*Panicum laevifolium* Hack).

Root Parasite (*Striga lutea*).

Transvaal: Marikana, 1919.

Rust (*Puccinia* sp.).

Transvaal: Skinners Court, Pretoria, 1907.

Rust (*Uromyces* sp.).

Transvaal: Skinners Court, Pretoria, 1909.

Natal: Langlaagte, 1915.

Smut (*Sorosporium* sp.).

Transvaal: Randfontein, 1913.

Natal: Mooi River, 1917.

Smut (*Ustilago* sp.).

Transvaal: Zoutpansberg, 1906; Johannesburg, 1909; Roberts Heights, 1915; Krugersdorp, 1915.

TALL FESCUE (*Festuca elatior* L.).

Ergot (*Claviceps* sp.).

Transvaal: Potchefstroom, 1912.

TAMBUTI GRASS (*Cymbopogon validus* Stapf).

Rust (*Puccinia* sp.).

Transvaal: Skinners Court, Pretoria, 1907.

Smut (*Sorosporium tambuti* P. Henn).

Transvaal: Zoutpansberg, 1911; Barberton, 1911.

TEFF (*Eragrostis abyssinica* Schrad).

Rust (*Uromyces pedicellata* Pole Evans).

Transvaal: Skinners Court, Pretoria, 1906, 1907, 1912; Krugersdorp, 1915.

TURPENTINE GRASS (*Cymbopogon excaratus* Stapf).

Smut (*Sorosporium tambuti* P. Henn).

Without locality, 1905.

Smut (*Ustilago Ischaemi* Fick).

Without locality, 1911.

GUAVA (*Psidium guajava* L.).

Anthracnose (*Gloeosporium* sp.).

Transvaal: Nelspruit, 1910.

Black Rot (*Sphaeropsis* sp.).

Cape Province: Manley Flats, 1914.

Chlorosis.

Cape Province: Kenilworth, 1920; Capetown, 1920.

HOLLYHOCK (*Althea rosea* Cav.).

Rust (*Puccinia malvacearum* Mont.).

Transvaal: Johannesburg, 1915; Pretoria, 1906, 1911; Groenkloof, 1915.

Natal: Inanda, 1881.

Cape Province: Somerset West, 1922.

Orange Free State: Sterkfontein, 1912.

IRIS (*Iris* spp.)

Leaf Spot (? *cause*).

Cape Province: Rosebank, 1920; Stellenbosch, 1922.

IRONWOOD (*Olea laurifolia*).

Trunk Rot [*Fomes rimosus* Berk., *F. australis* Fr., *F. applanatus* (Pers) Wallr.].

Cape Province: Eastern Conservancy, 1915.

Zululand: Qudeni, 1919.

KAFFIR CORN (*Sorghum vulgare* L.).

Downy Mildew (*Sclerospora graminicola* Schröt).

Zululand: Without locality, 1922.

Fusarium sp.

Natal: Ixopo, 1923.

Root Parasite, Witchweed (*Striga lutea*).

Without locality.

Smut (*Cintractia sorghi-vulgaris* Clint.).

Transvaal: Amsterdam, 1906, 1916; Johannesburg, 1913; Potchefstroom, 1912; Springs, 1914.

Natal: Inadi, near Greytown, 1914; Ixopo, 1923.

Cape Province: Grahamstown, 1914.

KEI APPLE (*Doryalis caffra* Hk. and Harv.).

Black Spot (*Phyllachora aberiae* P. Henn).

Cape Province: Uitenhage, 1906, 1912.

Transvaal: Zoutpansberg, 1911.

LEMON (*Citrus limonia* Osbeck).

Anthracnose (*Colletotrichum gloeosporioides* Penz).

Transvaal: Amsterdam, 1908.

Cape Province: Malmesbury, 1915; Bathurst, 1923.

Rhodesia: Without locality, 1919.

Bacterial Spot (*Bacillus citrimaculans* Doidge).

Cape Province: Simondium, 1914, 1915; Zuider Paarl, 1915; Cillier's Siding, 1915; Wynberg, 1915; Klein Drakenstein, 1915; Wellington, 1915; Capetown, 1922; Somerset West, 1922.

Occurs only in the winter-rainfall area.

Black Rot (*Diplodia natalensis* Pole Evans).

Transvaal: Graskop, 1916.

Natal: Verulam, 1911; Durban, 1923 (on leaves).

Rhodesia: Without locality, 1911.

Canker (*Bacterium citri* Hasse).

Transvaal: Warmbaths, 1908; Rustenburg, 1916. Dealt with by eradication of infected trees from 1916 onwards.

Chlorosis.

Transvaal: Hamanskraal, 1914; Sabie, 1917.

Cape Province: Constantia, 1921.

Concentric Ring Blotch.

Transvaal: Marikana, 1914. Common in the Transvaal.

Fruit Spot (*Phoma* sp.).

Causing superficial brown blemish; in most cases it would appear that the fungus invades spots caused by liberation of oil from rind.

Cape Province: Groot Drakenstein, 1915; Simondium, 1915; Paarl, 1915; Klein Drakenstein, 1915; Stellenbosch, 1915; French Hoek, 1915.

Gumming.

Cape Province: Paarl, 1914.

Leaf Blotch (*Phyllosticta adusta*).

Transvaal: Goudplaats Siding, 1919.

Leaf Spot (*Macrosporium citri* McAlp.).

Transvaal: Vaalkop, Marico District, 1909.

Cape Province: Bathurst, 1923.

Mold [*Penicillium digitatum* (Fr.) Sacc.].

Occurs commonly.

Scab or **Verrucosis** (? *Cladosporium citri* Mass.).

Occurs commonly in humid districts in Natal, Zululand, eastern parts of Cape Province, and at Nelspruit in the Transvaal.

LOGANBERRY (*Rubus* sp.).

Crown Gall (*Bacterium tumefaciens* Sm. and Towns).

Cape Province: Kenilworth, 1919, 1922.

LILY (*Lilium* spp.).

Fusarium sp.

Natal: Richmond, 1922.

LOQUAT (*Eriobotrya japonica* Lindl.).

Cladosporium sp.

Cape Province: Rondebosch, 1917.

Leaf Blotch [*Fabraea maculata* (Lev.) Atk.].

Transvaal: Pretoria, 1911, 1915; Johannesburg, 1918.

Scab (*Fusicladium Eriobotryae*).

Cape Province: Wynberg, 1915.

LUCERNE (*Medicago sativa* L.).

Anthracnose (*Colletotrichum trifolii* Bain).

Cape Province: Uitenhage, 1922.

Transvaal: Wonderboom, 1911; Potchefstroom, 1916.

Crown Rot (*Fusarium* sp.).

Transvaal: Pretoria, 1922; Eikenhof, near Johannesburg, 1923.

Diachea leucopoda (Bull) Rostr.

Transvaal: Pyramids, 1921.

Dodder (*Cuscuta* spp.).

Cape Province: Queenstown, 1894, 1908 (*C. medicaginis*).

Transvaal: Johannesburg, 1921 (*C. medicaginis*); Machadodorp (*C. trifolii*).

Downy Mildew (*Peronospora trifoliorum* De By).

Transvaal: Groenkloof, Pretoria, 1913, 1915; Welverdiend, 1922.

Natal: Ixopo, 1921.

Orange Free State: Reitz, 1921.

Leaf Spot [*Pseudopeziza Medicaginis* (Lib.) Sacc.].

Occurs commonly in all Provinces.

Phoma sp. (attacking stem).

Transvaal: White River, 1921.

Pleospora vulgatissima Speg.

Transvaal: Haenertsburg, 1910.

Cape Province: Without locality, 1910.

Physarum cinereum (Batsch) Pers.

Transvaal: Pyramids, 1921.

Root Disease (*Rhizoctonia Medicaginis* D. C.).

Natal: Weenen, 1912, 1917.

Sclerotial Disease (*Sclerotinia trifoliorum* Eriks).

Transvaal: Pretoria, 1907.

Rust (*Uromyces striatus* Schroet).

Occurs commonly.

MAIZE (*Zea Mays* L.).

Brown Rust (*Puccinia Maydis* Bereng).

Universally prevalent, but usually develops late in the season so that the damage is comparatively slight.

Dry Rot, Ear Rot [*Diplodia Zeae* (Schw.) Lev.].

Natal: Ixopo, 1912, 1913; Pepworth, 1916; Richmond, 1917; Mooi River, 1912; Estcourt, 1911, 1923.

Cape Province: Matatiele and Mount Currie, East Griqualand, 1918; Kentani, 1915.

Transvaal: Potchefstroom, 1919.

Rhodesia: Without locality, 1920.

Fusarium Rot (*Fusarium* sp.).

Transvaal: Bethal, 1914; Standerton, 1906.

Natal: Cedara, 1922, 1923: Yellow Kango and Hickory King cross very badly affected.

Cape Province: Somerset East.

Swaziland: Without locality, 1914.

Head Smut, Tassel Smut [*Sorosporium reilianum* (Kuhn) McAlp.].

Transvaal: Pretoria, 1912; Volksrust, 1913; Pan, 1917; Greylingstad, 1914; Pilgrims Rest, 1917; Garstfontein, Pretoria District, 1912; Standerton.

Natal: Colenso, 1912.

Orange Free State: Marseilles, 1911; Kestell Road, 1917.

Cape Province: Richmond, 1912; Delportshoop, 1913; Kingwilliamstown, 1911.

Leaf Blight (*Helminthosporium* sp.).

Cape Province: Vryburg, 1918.

Natal: Cedara, 1912, 1922, 1923. In 1923, Yellow Kango very severely affected, most plants devoid of living leaves soon after tasselling. Reported to have caused loss of crop in the Umzimkulu District; also severe at Howick.

Rhodesia: Without locality, 1910.

Portuguese East Africa: Catembe, 1909.

Leaf Mold (*Cladosporium Zeae* Pk.)

Natal: Cedara, 1912.

Transvaal: Skinners Court, Pretoria, 1910.

Leaf Spot (*Macrosporium Maydis* C. and E.).

Cape Province: Kingwilliamstown, 1911.

Pinking.

Transvaal: Leeuwdoorns, 1914; Vereeniging, 1914.

Cape Province: Debe Nek, 1914; Mount Coke, near Kingwilliamstown, 1914.

Natal: Utrecht, 1914.

Pondoland: 1915.

Red Rust (*Puccinia purpurea* Cke.).

Natal: Inanda, 1881.

Cape Province: Port Elizabeth, 1911.

Smut [*Ustilago Zeae* (Beck) Unger].

Cape Province: Maraisburg, 1911; Richmond, 1914; Graaff-Reinet, 1915; Seymour, 1916; Cradock, 1922; Adelaide, 1921; Kingwilliamstown, 1921; De Aar, 1922; Somerset East, 1923.

Variegation.

Cape Province: Amabele, 1915; Berlin, 1915; Bathurst, 1923.

Transvaal: Duivelskloof, 1914.

Natal: Maritzburg, 1911, 1922; Cedara, 1923. Also occurs throughout the coastal area.

Witchweed, Rooibloem (*Striga lutea*).

Transvaal: Barberton, 1903; Potchefstroom, 1904; Krugersdorp, 1907; Crocodile Valley, 1905; Kilnerton, 1923.

Is much more widely distributed than these records indicate.

MANGEL WURZEL (*Beta vulgaris* L., var. *macrorhiza*).

Leaf Blight (*Cercospora beticola* Sacc.).

Natal: Maritzburg, 1923; Mooi River, 1917; Estcourt, 1923.

Leaf Spot [*Cercosporella albo-maculans* (Ell. and Ev.) Sacc.].

Transvaal: Johannesburg, 1918.

Root Rot (*Rhizoctonia* sp.).

Natal: Mooi River, 1917; Weenen, 1912; Estcourt, 1923. In latter instance majority of fields very severely affected, with loss of entire crop in some cases. Ixopo District, 1923.

Rust [*Uromyces Betae* (Pers) Kuhn].

Cape Province: Somerset East, 1912.

MANGO (*Mangifera indica* L.).

Anthracnose, Ripe Rot (*Gloeosporium mangiferae* P. Henn).

Transvaal: Nelspruit, 1920, 1922; Wolhuterskop, 1920; Louws Creek, 1921; Barberton, 1922; Tzaneen, 1916; Karino, 1917.

Natal: Mt. Edgecombe, 1912; Tongaat, 1916.

Swaziland: Without locality, 1919.

Portuguese East Africa: Lourenco Marques, 1922.

Bacterial Spot (*Bacillus mangiferae* Doidge).

Transvaal: Barberton, 1910, 1922; Warmbaths, 1914; Nelspruit, 1913, 1923; Tzaneen, 1914; Louis Trichardt, 1919.

Natal: Malvern, 1911.

Mildew (*Oidium* sp.).

Transvaal: Nelspruit, 1921: destroying inflorescence.

MARROW (*Cucurbita pepo* L.).

Mildew (*Erysiphe cichoracearum* D.C.).

Occurs commonly.

MELON (*Cucumis melo* L.).

Leaf Spot (*Macrosporium cucumerinum* E. and Z.).

Cape Province: Kraaifontein, 1921.

Mildew (*Erysiphe cichoracearum* D.C.).

Transvaal: Pietersburg District, 1917.

Orange Free State: Marquard, 1920.

Wilt or **Blight** (? *Bacillus tracheiphilus* Erw. Sm.).

Transvaal: Kliptown, 1922: vessels choked with bacteria; identity of organism has not been established by culture.

MULBERRY (*Morus* spp.).

Blight [*Bacterium Mori* (Boy et Lamb)].

Transvaal: Amsterdam, 1914; Pretoria, 1918, 1920.

Natal: Dundee, 1913.

Cape Province: Somerset West, 1922.

Leaf Spot (*Septogloeum Mori* Br. et Cav.).

Transvaal: Delmas, 1920; Orchards, 1921; Wolmaransstad, 1918; Johannesburg, 1918; Pretoria, 1909; Heidelberg, 1911.

Cape Province: Conway, 1912; Kingwilliamstown, 1906.

Orange Free State: Kroonstad, 1915.

MEXICAN MARIGOLD (*Tagetes minuta*).

Dodder (*Cuscuta* sp.).

Transvaal: Pretoria, 1923.

NAARTJE (*Citrus nobilis* Lour).

Anthracnose (*Colletotrichum glocosporioides* Penz).

Cape Province: Uitenhage, 1920.

Bacterial Spot (*Bacillus citrimaculans* Doidge).

Cape Province: Simondium, 1914; La Motte, 1917.

Black Rot (*Diplodia natalensis* Pole Evans).

Natal: Coast districts.

Rhodesia: Without locality, 1912.

Concentric Ring Blotch.

Portuguese East Africa: Mozambique, 1919.

Transvaal: A common disease usually less severe than on orange leaves.

Corky Scab (*? cause*).

Natal: Verulam; curious small circular corky growths, have been reported several times from Natal and Zululand and from Rhodesia.

Sooty Mold (*Capnodium citricolum* McAlp.).

Cape Province: Bedford, 1916.

NARCISSUS (*Narcissus* sp.).

Fusarium ? bulbigenum.

Cape Province: Stellenbosch, 1918.

NASTURTIUM (*Tropoeolum majus* L.).

Mildew (*Oidiopsis taurica* Lev.).

Transvaal: Pretoria, 1908-9.

Cape Province: Kentani, 1913; Capetown, 1923.

NECTARINE (*Prunus persica* Stokes var.).

Crown Gall (*Bacterium tumefaciens* Sm. and Towns).

Transvaal: Wakkerstroom, 1910.

Freckle (*Cladosporium carpophilum* Thum).

Transvaal: Middelburg, 1909.

Cape Province: Ceres, 1917; Cradock, 1923.

Leaf Curl [*Taphrina deformans* (Fckl.)].

Transvaal: Johannesburg, 1920.

Cape Province: Koelenhof, 1921; Plumstead, 1921.

Rust (*Puccinia pruni-spinosae* Pers).

Cape Province: Elsenburg, 1906; Capetown, 1912.

OAK (*Quercus* spp.).

Botryodiplodia sp.

Transvaal: Pretoria, 1917.

Cape Province: Caledon, 1914.

Calospora aransiaca (Fabr.) Sacc.

Cape Province: Wellington, 1912.

Coryneum disciforme Kze. et Sch.

Cape Province: Wellington, 1910, 1912.

Epicoccum sp.

Transvaal: Irene, 1912.

Microstroma album (Desm.) Sacc.

Cape Province: Constantia, 1906; Maclear, 1912.

Natal: Maritzburg, 1911; Inanda.

Transvaal: Lydenburg, 1911; Pretoria, 1918.

Oidium quercinum Thuem (Perithecia not observed).

Orange Free State: Harrismith, 1923.

Cape Province: Ceres, 1920; Rosebank, 1909, 1921; Capetown, 1920; Kenilworth, 1920, 1922; Constantia, 1922; Stellenbosch, 1923.

Transvaal: Ermelo, 1921; Derdepoort, 1923.

Pestalozzia sp.

Transvaal: Irene, 1912.

Stereum hirsutum (Willd.) Fr.

Transvaal: Vereeniging, 1915.

OATS (*Avena sativa* L.).

Black Rust (*Puccinia graminis* Pers).

Transvaal: Skinners Court, Pretoria, 1905, 1908; Standerton, 1906.

Cape Province: Elsenburg.

Natal: Cedara, 1922.

Covered Smut [*Ustilago levis* (Kell. and Sw.) Magn.).

Transvaal: Irene, 1908; Ermelo.

Cape Province: Lovedale, 1917; Elsenburg.

Rhodesia: Without locality, 1919.

Crown Rust [*Puccinia coronifera* (Kleb)].

Natal: Cedara, 1906, 1911.

Transvaal: Skinners Court, Pretoria, 1906; Standerton, 1906; Zoutpansberg, 1908; Potchefstroom, 1910.

Rhodesia: Without locality, 1911.

Leaf Blotch (*Septoria* sp.).

Cape Province: Belville, 1920.

Loose Smut [*Ustilago avenae* (Pers) Jens.].

Cape Province: Queenstown, 1919; Rosebank, 1920; Rosmead; Elsenburg.

Transvaal: Johannesburg, 1913.

OLEANDER (*Nerium Oleander* L.).

Bacterial Knot [? *Bacterium Oleae* (Arcang) Trev.].

Transvaal: Johannesburg, 1908, 1919.

Cape Province: Capetown, 1914, 1917.

ONION (*Allium Cepa*, L.).

Bulb Rot (*Botrytis Allii*).
Cape Province: Molteno, 1921.
Transvaal: Mara, Zoutpansberg, 1923.

Bulb Rot (*Sclerotinia* sp.).
Cape Province: Without locality.

Concentric Ring Disease (*Vermicularia circinans* Berk).
Cape Province: Grootfontein.

Downy Mildew (*Peronospora Schleideni* Ung.).
Transvaal: Potchefstroom, 1911; Pretoria, 1912; Christiana, 1914; Eikenhof, 1917.
Cape Province: French Hoek, 1918; Aliwal North.

Mold (*Macrosporium cladosporioides* Desm.).
Cape Province: Aliwal North, 1912

Mysterosporium Alliorum Berk.
Natal: Muden, 1912.

ORANGE (*Citrus sinensis* Osbeck).

Anthracnose, Die Back (*Colletotrichum gloeosporioides* Penz). Occurs commonly wherever orange trees are grown.

Bacterial Spot (*Bacillus citrimaculans* Doidge).
Cape Province: Simondium, 1914; La Motte, 1917; Somerset West, 1922.

Black Rot (*Diplodia natalensis* Pole Evans).
Natal: Warner Beach, 1914; Maritzburg, 1914.
Cape Province: Uitenhage.
Transvaal: Pretoria, 1914, 1917.
Rhodesia: Without locality, 1915.

Black Rot of Navel Oranges (*Alternaria citri* Penz).
Cape Province: Fort Beaufort, 1921; Graaff-Reinet

Blue Mold (*Penicillium italicum* Wehm).
Occurs commonly.

Canker (*Bacterium citri* Hasse).
Transvaal: Rustenburg, Waterberg, and Pretoria Districts, 1909-1918. Has been dealt with by eradication measures.

Chlorosis.

Transvaal: Marico, 1911; Johannesburg, 1913; Hartebeestfontein, 1915; Rustenburg, 1921; Haakdoorn, 1923.

Cape Province: Steynsburg, 1914; Steinkopf, 1917; Selborne, 1917.

Natal: Buccleuch, 1915.

Collar Rot (Vrot Pootje).

Transvaal: Vlakhoek, 1911; Fort Edward, 1914; Potgietersrust, 1916; Nelspruit, 1919; Zoutpansberg District, 1919; Rustenburg District; Waterval Onder, 1913.

Natal: Maritzburg, 1913; Stanger, 1913; Krantzkop, 1919.

Cape Province: Humansdorp District, 1915; Wellington, 1916.

Concentric Ring Blotch.

Occurs commonly in the Transvaal; also reported from Natal, the Orange Free State, and Rhodesia.

Die Back (*Phoma omnivora* McAlp.): see also *anthracnose*.

Orange Free State: Vredefort, 1914.

Dodder (*Cuscuta cassythoides*).

Natal: Krantzkloof.

Fruit Spot (*Phoma* sp.): see also under *Lemon*.

Cape Province: Riversdale, 1916; Fort Beaufort, 1916.

Transvaal: Nelspruit, 1918.

Fusarium sp. (attacking branches).

Transvaal: White River, 1922.

Green Mold [*Penicillium digitatum* (Fr.), Sacc.].

Occurs commonly.

Leaf Mottling, Californian Leaf Mottling.

Transvaal: Ottoshoop, 1923; De Kroon, 1922; Zebedelia, 1922.

Leaf Spot (*Pleospora disrupta* McAlp.).

Cape Province: Wellington, 1912.

Lenzites sp.

Transvaal: Hennops River, 1911.

Scaly Bark.

Transvaal: Steenbokfontein, 1919; Zeerust, 1922; Louis Trichardt, 1922; Rustenburg District, 1922; Pretoria, 1922; Tzaneen, 1922; Selati, 1923.

Septobasidium sp.

Natal: Durban, 1913; Plains, 1921.

Sooty Mold (*Capnodium citricolum* McAlp.).

Cape Province: Adelaide, 1919; Bedford, 1916; Cambridge, 1918.

Transvaal: Johannesburg, 1909; Rustenburg, 1911; Elandsrivier, 1918; Haenertsburg, 1919.

Orange Free State: Zastron, 1921.

Natal: Escombe, 1916.

Sun Scald.

Cape Province: Grahamstown, 1919; Uitenhage, 1923.

Verrucosis (? *Cladosporium citri* Mass.).

Natal: Huletts, 1905; Buccleuch, 1916; Zululand, 1921.

Cape Province: Port Elizabeth. Rare on this host.

PALM (*Phoenix* sp., etc.).

Colletotrichum sp.

Cape Provinnce: Capetown, 1921.

Exosporium palmivorum Sacc.

Natal: Durban, 1915.

Graphiola phoenicis, Poit.

Common in the greenhouse and in the open.

PARSNIP (*Pastinaca sativa* L.).

Early Blight (*Cercospora Apii* Fres., var. *Pastinaceae*).

Natal: Cedara, 1911.

PARSLEY (*Petroselinum hortense* Hoffm.).

Leaf Spot (*Septoria petroselini* Desm.).

Natal: Maritzburg, 1911.

PAWPAW (*Carica Papaya* L.).

Leaf and **Fruit Spot** (*Phoma* sp.).

Transvaal: Paardeplaats, Pietersburg District, 1917.

Macrosporium sp.

Transvaal: Barberton, 1909.

Portuguese East Africa: Without locality, 1913.

Ripe Rot (*Gloeosporium papayae* P. Henn).

Natal: Winklespruit, 1917; Hillarys, 1912.

Transvaal: Nelspruit, 1921; Louws Creek, 1917; Duivelskloof, 1919.

Cape Province: Cambridge, 1922.

PEA (*Pisum* spp.).

Downy Mildew (*Peronospora Viciae* Berk).

Cape Province: Ceres.

Leaf Spot (*Ascochyta Pisi* Lib.).

Transvaal: Pretoria, 1914.

Cape Province: Stellenbosch, 1914; Kentani, 1917.

Mildew (*Erysiphe Polygoni* D.C.).

Transvaal: Pretoria, 1907; De Kroon, 1906; Potchefstroom, 1912.

PEACH (*Prunus Persica* L.).

Brown Rot [*Sclerotinia fructigena* (Pers) Schroet].

Transvaal: Pretoria, 1915.

Canker (*Calosphaeria princeps* Tvl.).

Orange Free State: Parys, 1920.

Chlorosis.

Transvaal: Nylstroom, 1923.

Cape Province: Uniondale Road, 1921; Bonnievale, 1923.

Crown Gall (*Bacterium tumefaciens* Sm. and Towns).

Common on peaches and peach stocks throughout the country.

Die Back [*Cytospora leucostoma* (Pers) Sacc.].

Orange Free State: Parys, 1920.

Freckle (*Cladosporium carpophilum* Thum).

Extremely common, especially in the Transvaal.

Leaf Curl [*Taphrina deformans* (Fckl.) Tul.].

Is of frequent occurrence in seasons when the rain starts early; was recorded from numerous localities in all Provinces in October, 1917, less numerous records for other years.

Mold (*Rhizopus nigricans* Ehbg.).

Cape Province: Somerset West, 1916; Stellenbosch, 1921. Fruit rots, starting from the stem end.

Powdery Mildew (*Sphaerotheca pannosa* Lev., var. *Persicae*).

Natal: Cedara, 1922.

Cape Province: Simondium, 1912.

Rust (*Puccinia pruni-spinosae* Pers).

Of common occurrence in all four Provinces.

Septobasidium sp.

Transvaal: Barberton, 1912.

Shot Hole (*? cause*).

Cape Province: Without locality.

Silver Leaf (*Stereum purpureum* Fr.).

Cape Province: Stellenbosch, 1922.

Silver leaf also recorded from several other localities in the Cape Province and in the Transvaal, without reference to the causal organism.

Yellows.

Cape Province: Middelburg; Steynsburg.

PEANUT (*Arachis hypogea* L.).

Leaf Blight (*Septogloeum arachidis* Rac.).

Transvaal: Zoutpansberg, 1910; Ledge, 1910; Settlers, 1909; Pretoria, 1919; Nelspruit, 1919; Potgietersrust, 1921.

Natal: Maritzburg, 1922; Cedara, 1923.

Root Parasite (*Melasma* sp.).

Transvaal: Potgietersrust, 1922.

Root Rot (*Rhizoctonia* sp.).

Transvaal: Pietersburg, 1923; Potgietersrust, 1923.

Rosette Disease.

Affected plants are sickly, stunted, and sterile; the terminal shoots turn yellow and get stunted; growth ceases, and any nuts forming on the pegs rot off. The whole plant gradually turns yellow and curls up.

Transvaal: Duivelskloof, 1910, common in Agatha and Puzela Districts, 1910; Settlers, 1909, 1923; Potgietersrust, 1921; Pietersburg, 1923; Naboomspruit, 1923; Rustenburg, 1923; Pilansberg, 1923.

Sclerotial Disease (*Sclerotium* sp.).

Transvaal: Duivelskloof, 1914.

PEAR (*Pyrus communis* L.).

Bacterial Blight of Blossoms (*Bacterium nectarophilum* Doidge).

Cape Province: Elsenburg, 1916; Stellenbosch, 1916.

Bitter Rot [*Glomerella cingulata* (Berk) Sp. and Van Schrenk].

Transvaal: Pretoria, 1911.

Canker (*Nectria ditissima* Tul.).

Cape Province: Kimberley, 1913.

Chlorosis.

Cape Province: Graaff-Reinet, 1923; Douglas, 1922; Bonnievale, 1923.

Cracking Disease (*Coniothecium chomatosporum* Corda).

Transvaal: Ermelo, 1913.

Natal: Van Reenen, 1914.

Cape Province: Qumbu, 1914; Wynberg, 1922; Stellenbosch, 1922.

Crown Gall (*Bacterium tumefaciens* Sm. and Towns).

Transvaal: Johannesburg, 1912; Pienaars Poort, 1916.

Natal: Langlaagte.

Cape Province: Bonnievale, 1923.

Lasiodiplodia sp.

Cape Province: Mulders Vlei, 1914.

Leaf Blight [*Fabraea maculata* (Lev.) Atk.].

Natal: Balgowan, 1914; Donnybrook, 1914; Richmond, 1922.

Transvaal: Pretoria, 1915.

Cape Province: Little Brak River, 1923.

Orange Free State: Harrismith, 1923.

Leaf Spot (*Septoria piricola* Desm.).

Cape Province: Krakeel, 1920; Avontuur, 1922; Grahamstown, 1912; Kingwilliamstown, 1911.

Scab (*Venturia pirina* Aderh.).

Cape Province: Stellenbosch, 1919; Elsenburg, 1917; French Hoek, 1919; Ceres, 1913; Umtata, 1917; Groot Drakenstein, 1919; George, 1919; Seymour, 1905; Grahamstown, 1917; Constantia, 1906; Kingwilliamstown.

Transvaal: Carolina, 1907.

Natal: Ixopo, 1912.

Silver Leaf (*Stereum purpureum* Fr.).

Cape Province: Stellenbosch, 1922.

Sour Sap.

Cape Province: Stellenbosch, 1920.

PEPPER TREE (*Schinus molle* L.).

Anthracnose (*Glocosporium* sp.).

Cape Province: Kingwilliamstown, 1920; Grahamstown, 1914.

Natal: Maritzburg, 1913.

Leaf Spot (? *Bacterium* sp.).

Transvaal: Irene, 1912.

PERSIMMON (*Diospyros virginiana* L.).

Damping Off (*Fusarium* sp.).

Transvaal: Vereeniging, 1922.

PHLOX (*Phlox* sp.).

Leaf Spot (*Cercospora omplacodes* Ell. and Hoh.).

Natal: Cramond, 1913.

PINE (*Pinus* spp.).

Capnodium Pini B. and C.

Cape Province: Table Mountain, 1906; Stellenbosch, 1919; Keiskama Hoek, 1917.

Coniothecium sp.

Cape Province: Stutterheim, 1920.

Diplodia pinea Kickx.

Cape Province: Cathcart, 1913; Nqadu Heights, 1921; Fort Cunninghame, 1909, 1913; Isikeni, 1915; Port Elizabeth, 1919; Mount Ayliff, 1917; Kokstad, 1915; Tokai, 1900; Jessievale, 1916; Amatola Mountains, 1915.

Natal: Cedara, 1921, 1923.

Orange Free State: Harrismith, 1910.

Fusarium sp.

Cape Province: Knysna, 1921; Hankey, 1921.

Naemocyclus nivens (Pers) Sacc.

Transvaal: Irene, 1912.

Pestalozzia funerea Desm.

Cape Province: Cathcart, 1913.

Transvaal: Irene, 1912; Fountains, Pretoria, 1919.

Natal: Cedara, 1914; Eshowe, 1922.

Pestalozzia Hartigii Tubeng.

Cape Province: Caledon, 1918.

Transvaal: Graskop, 1915.

Pestalozzia spp.

Natal: Cedara, 1921; Port Durnford, 1916.

Cape Province: Stutterheim, 1920; Knysna, 1921.

Transvaal: Middelburg, 1921; Irene, 1912.

Phoma penicola (Zopf) Sacc.

Cape Province: Katberg, 1914; Jessievale, 1914; Keiskama Hoek, 1913.

Phoma abietina Hartig.

Transvaal: Ermelo, 1910.

Orange Free State: Buckland Downs, 1916.

Phoma sp.

Zululand: Fort Durnford, 1916.

Thelephora terrestris Ehrh.

Transvaal: Pan, 1910.

Cape Province: Knysna, 1920.

Zululand: Eshowe, 1919.

PINEAPPLE (*Ananas sativus* Schult.).

Brown Spot (*Penicillium* sp.).

Common in eastern part of Cape Province and in Natal, 1920, 1923.

Root Rot or **Crown Rot** (? *cause*).

Cape Province: Clumber, 1920.

PLANE (*Platanus* sp.).

Canker (*Cytospora* sp.).

Natal: Greytown, 1922.

PLUM (*Prunus* sp.).

Brown Rot [*Sclerotinia fructigena* (Pers) Schroet].

Cape Province: Retreat, 1919.

Crown Gall (*Bacterium tumefaciens* Sm. and Towns).

Cape Province: Oliphants Hoek, 1921; East Griqualand, 1917; Simondium, 1922.

Transvaal: Rustenburg, 1922; Wakkerstroom, 1914; Klerksdorp, 1917; Hennops River, 1919.

Natal: Maritzburg, 1912; Hattingh Spruit, 1914.

Chlorosis.

Cape Province: Wellington, 1920, 1922; Elgin, 1922; Bonnievale, 1923.

Transvaal: Nylstroom, 1923.

Corticium sp.

Natal: Hilton Road, 1919.

Die Back (*Cytospora* sp.).

Orange Free State: Harrismith, 1912.

Die Back (*Botryosphaeria* sp.).

Cape Province: Du Toit, 1920.

Gumming (*? cause*).

Cape Province: Du Toit, 1920; Robertson, 1921.

Rust (*Puccinia pruni-spinosae* Pers).

Cape Province: Groot Drakenstein, 1912; Glenlyon, 1915; Queenstown, 1912; Grahamstown, 1912.

Transvaal: Lake Chrissie, 1911; Bethal, 1911; Nelspruit, 1911.

Shot Hole (*Bacterium* sp.).

Natal: Cedara, 1920; Maritzburg, 1916.

Transvaal: Johannesburg, 1918; Pretoria, 1918.

Silver Leaf (*Stereum purpureum* Pers).

Cape Province: La Motte, 1913; Rondebosch, 1921, 1922; Newlands, 1921; Wynberg, 1921; Stellenbosch, 1921, 1922; Retreat, 1922; Somerset West, 1922.

Sun Scald.

Cape Province: Without locality.

Trunk Rot (*Schizophyllum commune* Fr.).

Cape Province: Groot Drakenstein, 1919; Wellington, 1919.

POPLAR (*Populus* spp.).

Canker [*Cytospora chrysosperma* (Pers) Fr.].

Cape Province: Bedford, 1921.

Crown Gall (*Bacterium tumefaciens* Sm. and Towns).

Cape Province: Aliwal North, 1912; Maclear, 1912; Toise River, 1912.

Orange Free State: Zastron, 1912.

Didymosphaeria populina Vaill.

Cape Province: Kingwilliamstown, 1916.

Leaf Curl (*Taphrina aurea* Fr.).

Cape Province: Constantia, 1906, 1908; Stellenbosch, 1908.

Leaf Spot (*Marssonia castagnei* Desm. and Mont.).

Cape Province: Claremont, 1909.

Nectria ditissima Tul.

Cape Province: Capetown, 1907.

Phyllosticta sp.

Transvaal: Irene, 1912.

Polyporus lucidus.

Cape Province: Despatch, 1921.

Rust [*Melampsora aecidioides* (D.C.) Schroet].

Cape Province: Capetown, 1909; Wellington, 1911; Groot Drakenstein, 1910; Stellenbosch, 1923; Kingwilliamstown, 1916.

Orange Free State: Bethlehem, 1916.

Transvaal: Woodbush, 1913.

Schizophyllum commune Fr.

Cape Province: Kingwilliamstown, 1915.

POTATO (*Solanum tuberosum* L.).

Black Dot Disease (*Vermicularia varians* Duc.).

Natal: Mooi River, 1914.

Transvaal: Pretoria, 1913; Pietersburg, 1922; Klipriviet, 1921.

Black Heart.

Natal: Cedara, 1916; Hermansburg, 1914.

Black Leg (*Bacillus solanisaprus* Harrison).

Natal: Hattingh Spruit, 1919.

Orange Free State: Tweespruit, 1919.

Corky Scab [*Spongospora subterranea* (Wallr.) Johns.]

Transvaal: Dullstroom, 1911.

Dry Rot (*Fusarium* sp.).

Common in stored tubers.

Dry Rot (*Verticillium alboatrum* Reinke et Berth.).

Cape Province: Capetown, 1922.

Early Blight (*Macrosporium solani* E. and Mart.).

Occurs commonly in all Provinces.

Glassy Centre.

Transvaal: Val, 1910.

Hollow Heart.

Natal: Elandskop, 1922; Van Reenen, 1923.

Internal Brown Fleck.

A common trouble, especially severe on the high veld.

Late Blight (*Phytophthora infestans* De Bary).

Transvaal: Belfast, 1915; Witbank, 1913; Middelburg, 1914; Alkmaar, 1921; Pretoria, 1913; Roodepoort, 1913; Krugersdorp, 1915; Boksburg, 1917; Ermelo, 1919.

Cape Province: Hankey, 1919; Plettenberg Bay, 1921; Mount Ayliff, 1917.

Orange Free State: Swinburne, 1912.

Mosaic Disease.

Natal: Cedara, 1923.

Rhizoctonia Disease (*Corticium vagum* B. and C., var. *Solani* Ber.).

Occurs commonly.

Scab (*Actinomyces chromogenus* Gasp.).

Extremely common.

Sclerotial Disease (*Sclerotium* sp.).

Transvaal: Maraisburg, 1913.

Natal: Winklespruit, 1912; Muden, 1914.

Wart Disease (*Synchitrium endobioticum* Perc.).

Natal: Impendhle Division, 1921-22.

Wilt (*Bacterium solanacearum*, Erw. Sm.).

Natal: Cedara, 1923; Durban, 1921.

Transvaal: Pretoria, 1918; Haenertsburg, 1920; Carolina, 1914; Duivelskloof, 1917, 1922; Elands River, 1919; Delarey, 1917; Pietersburg District, 1921; Tzaneen, 1921; Ottoshoop, 1922; New Agatha, 1921; Munnik, 1922; Premier Mine, 1915; Benoni, 1918.

Orange Free State: Ladybrand, 1922; Bloemfontein, 1921; Boshof, 1922; Marquard, 1922.

Cape Province: Mafeking, 1918; Wellington, 1915; Vlottenberg, 1916; Stellenbosch, 1910; Vygeboom, 1916.

PRIVET (*Ligustrum vulgare* L.).

Ascochyta sp.

Transvaal: Irene, 1912.

Bacterium sp.

Transvaal: Benoni, 1922.

PRUNE (*Prunus* sp.).

Crown Gall (*Bacterium tumefaciens* Erw. Sm.).

Cape Province: Swellendam, 1921.

Rust (*Puccinia pruni-spinosae* Pers).

Cape Province: Koelenhof, 1920; Robertson, 1921.

Silver Leaf (*Stereum purpureum* Pers).

Cape Province: Rondebosch, 1921.

Sun Scald.

Cape Province: Orchard Siding, 1910; Robertson, 1921.

PUMPKIN (*Cucurbita pepo* L.).

Leaf Spot (*Septoria citrulli* E. and E.).
Transvaal: Cedarmount, 1917.

Mildew (*Erysiphe cichoracearum* D.C.).
Occurs commonly.

QUINCE (*Cydonia oblonga* Mill).

Bitter Rot [*Glomerella cingulata* (Berk) Sp. and Var. Schr.]
Natal: Impendhle, 1923.

Black Rot (*Physalospora cydoniae* Hes.).
Cape Province: Muizenberg, 1912; Somerset West, 1922.
Orange Free State: Jacobsdal, 1912.

Leaf Blotch [*Fabraea maculata* (Lev.) Atk.].
Occurs commonly.

Quince Knot (? *Bacterium tumefaciens* Sm. and Towns).
Common.

Sunburn.
Cape Province: Bonnievale, 1923.

RADISH (*Raphanus sativus* L.).

Downy Mildew (*Peronospora parasitica* De Bary).
Cape Province: Groot Drakenstein, 1914.

RAPE (*Brassica napus* L.).

Black Rot [*Bacterium campestre* (Pam), Sm.].
Natal: Cedara, 1923.

RHUBARB (*Rheum rhaponticum* L.).

Rust (*Aecidium rubellum*).
Cape Province: Middelburg, 1923.
Transvaal: Ermelo, 1908.

Wilt and **Foot Rot** (*Phytophthora parasitica* var. *Rhei*).
Cape Province: Uitenhage, 1923.
Transvaal: Leeuwdoorns, 1913; Potchefstroom, 1915. These two Transvaal records probably refer to same disease, but only sterile mycelium was detected.

ROSE (*Rosa* spp.).

Bud Rot (*Botrytis cinerea* Pers).
Transvaal: Premier Mine, 1907.

Canker (*Coniothyrium fuckelii* Sacc.).
Transvaal: Bethal, 1921; Heidelberg, 1921; Standerton, 1922; Johannesburg, 1920; Pretoria, 1921.
Orange Free State: Harrismith, 1916; Westminster, 1921.
Cape Province: East London, 1921; Queenstown, 1920; Aliwal North, 1922.
Natal: Maritzburg, 1922.
Basutoland: 1921.

Canker (*Physalospora cydoniae* Hes.).
Cape Province: Bonnievale, 1922.

Crown Gall (*Bacterium tumefaciens* Sm. and Towns).
Cape Province: Rosebank, 1912; Great Brak River, 1917; Wynberg, 1922.
Orange Free State: Bloemfontein, 1916.

Chlorosis.
Cape Province: Bonnievale, 1923.

Leaf Blotch [*Diplocarpon rosae* (Leb.)].
Occurs commonly.

Mildew (*Sphaerotheca pannosa* Lev.).
Occurs commonly.

Rust (*Phragmidium subcorticum*).
Transvaal: Pretoria, 1910; Lake Chrissie, 1916.
Cape Province: Rondebosch, 1920; Rosebank, 1921; Somerset West, 1922.

RYE (*Secale cereale*, L.).

Black Rust (*Puccinia graminis* Pers).
Cape Province: Grahamstown, 1921.

Brown Rust (*Puccinia dispersa* Eriks and Henn).
Natal: Cedara, 1911.

SEVILLE ORANGE (*Citrus Aurantium* L.).

Scab or **Verrucosis** (? *Cladosporium citri*, Mass.).
Natal: Maritzburg, 1920; Amatikulu, Zululand, 1921.
Pondoland: Lusikisiki, 1923.

SISAL HEMP (*Agave sisalana* Perr.)

Collectotrichum Agave Cav.

Natal: Winklespruit, 1916.

Leaf Blotch (*cause obscure*).

Transvaal: Tzaneen, 1916; Barberton, 1913; Louis Trichardt, 1920; Haenertsburg, 1910.

Portuguese East Africa: Without locality, 1916.

Also reported from Nairobi and Nyasaland.

SNAPDRAGON (*Antirrhinum majus* L.).

Stem Rot (*Phoma* sp.).

Cape Province: East London, 1917.

Wilt (*Fusarium* sp.).

Transvaal: Pretoria, 1920; Johannesburg, 1915.

SNEEZEWOOD (*Ptaeroxylon utile* Eckl. and Zeyh.).

Trunk Rot (*Fomes rimosus* Berk).

Cape Province: Eastern Conservancy, 1915.

STOCK (*Matthiola* sp.).

Wilt (*? Fusarium* sp.).

Cape Province: Stutterheim, 1922.

STRAWBERRY (*Fragaria* spp.).

Brown Rot (*Botrytis* sp.).

Transvaal: Pretoria District, 1921.

Leaf Spot [*Sphaerella Fragariae* (Tul.) Sacc.].

Occurs commonly.

Sclerotial Disease (*Sclerotium Rolfsii* Sacc.).

Transvaal: Premier Mine, 1919.

SUGAR CANE (*Saccharum officinarum* L.).

Cephalosporium sacchari.

Natal: Various localities on Natal coast.

Helminthosporium sacchari.

Natal: Throughout coastal area.

Leptosphaeria sacchari V. B. d. H.
Natal: Throughout coastal area.

Melanconium sacchari Mass.
Natal: Various localities on coast.
Portuguese East Africa: Xinavane, 1921.

Mosaic Disease.
Natal: Various localities on coast.

Phoma sp.
Natal: Various localities on coast.

Root Disease (? *Himantia stellifera*).
Natal: Various localities on coast.

Top Rot [? *Cobb's Disease, Bact. vascularum* (Cobb.), Sm.].
Natal: La Mercy.

SUNFLOWER (*Helianthus annuus* L.).

Leaf Blotch (*Septoria Helianthi*).
Cape Province: Capetown, 1918.
Natal: Maritzburg, 1922.

SWEDE (*Brassica campestris* L.).

Soft Rot (*Bacillus carotovorus* Jones).
Natal: Elandskop, 1922.

SWEET PEA (*Lathyrus odoratus* L.).

Mildew (*Oidium* sp.).
Occurs commonly.

Streak (*Bacillus Lathyri*).
Cape Province: Wynberg, 1914.

SWEET POTATO (*Ipomoea batatas* Poir)

Brack Injury.
Cape Province: Little Brak River, 1923.

Leaf Spot (*Cercospora* sp.).
Natal: Maritzburg, 1923.

Root Parasite (*Striga orobanchoides*).
Transvaal: Groot Marico, 1923; large areas of plants destroyed by parasite.

Scab (*Actinomyces* sp.).
Cape Province: Little Brak River, 1923.

Storage Rot (*Fusarium* sp.).
Cape Province: Little Brak River, 1923.

Storage Rot (*Rhizopus nigricans* Ehbg.).
Cape Province: Little Brak River, 1923.

Sun Scorch.
Cape Province: Little Brak River, 1923.

TEOSINTE (*Euchlaena mexicana* Schrad).

Witchweed or **Rooibloem** (*Striga lutea*)
Locality not stated.

TOBACCO (*Nicotiana* spp.).

Angular Leaf Spot (*Bacterium angulatum*).
Transvaal: Rustenburg District, 1923.
Rhodesia: Without locality, 1920.

Broom Rape (*Orobanche ramosa*).
Cape Province: Stellenbosch District, 1923.

Damping Off in Seed Beds (*Rhizoctonia* sp.).
Transvaal: Krugersdorp, 1912; common in Rustenburg District, 1922.

Leaf Spot (*Cercospora Nicotianae* Ell. et Ev.).
Swaziland: 1910.
Rhodesia: 1913.

Leaf Spot (*Ascochyta Nicotianae* Pers).
Transvaal: Pretoria, 1907.

Mosaic Disease.
Transvaal: Barberton, 1913; Pretoria, 1923; Rustenburg, 1922.
Cape Province: Elsenburg, 1922; Stellenbosch, 1922; Piquetberg, 1915.

Powdery Mildew, White Rust (*Oidium tabaci* Thuem.).
Occurs commonly.

Red Rust (*Macrosporium longipes* Ell. et Ev.).
Transvaal: Barberton, 1922; Rustenburg, 1921; Magaliesburg, 1921; Pyramids, 1923.
Natal: Umbogintwini, 1923.
Cape Province: Oudtshoorn, 1922; Komgha, 1913.

White Speck (*Macrosporium tabacinum* Ell. et Ev.).

Transvaal: Piet Retief, 1920; Rustenburg, 1918; Barberton, 1913.

Cape Province: Stellenbosch, 1916.

Natal: Without locality, 1917.

Wildfire (*Bacterium tabaci*).

Transvaal: Rustenburg District, 1921, 1923; Pretoria District, 1922-23; Piet Retief, 1921; Groot Marico, 1921; Brits, 1923; Parys, 1922.

Cape Province: Stockenstrom District, 1923.

Natal: Ixopo District, 1923; Nkandhla, 1923.

Wilt (*Bacterium solanacearum* Erw. Sm.).

Natal: Frasers, 1913; Tongaat, 1918.

Witchweed (*Striga lutea*).

Transvaal: Springbok Flats, 1923, on *Nicotiana rustica*. *Striga orobanchoides* was reported in 1923 on *N. rustica* at Vereeniging.

TOMATO (*Lycopersicum esculentum* Mill).

Anthracnose (*Colletotrichum phomoides*).

Transvaal: Barberton, 1922; Pretoria, 1918.

Bacterial Wilt (*Bacterium solanacearum* Erw. Sm.).

Natal: Durban, 1916; Maritzburg, 1911; Edendale, 1921.

Transvaal: Johannesburg, 1921; Pretoria, 1917; Nelspruit, 1917, 1919; Potgietersrust, 1916; Hectorspruit, 1919; Alkmaar, 1917; Rustenburg, 1910.

Blossom End Rot.

Transvaal: Balfour, 1920; Pretoria, 1920; Messina, 1917.

Orange Free State: Harrismith, 1920; Bloemfontein, 1916.

Cape Province: Groot Drakenstein, 1914; Capetown, 1916; Plettenberg Bay, 1922; Muizenberg, 1920; Kraaifontein, 1920; Capetown, 1923.

Natal: Maritzburg, 1916.

Canker (*Bacterium vesicatorium* Doidge).

Transvaal: Pretoria, 1922; Zandfontein, 1922.

Early Blight (*Macrosporium solani* Ell. et Mart.).

Cape Province: Vryburg, 1920; Capetown, 1918; Kenilworth, 1911; Uitenhage.

Late Blight (*Phytophthora infestans* De Bary).

Natal: Stanger, 1922.

Leaf Roll?
Cape Province: Capetown, 1922.

Leaf Spot (*Septoria lycopersici* Speg.).
Common in all Provinces.

Mosaic Disease.
Transvaal: Pretoria, 1917, 1923.

Wilt (*Fusarium* sp.).
Cape Province: Douglas, 1923.

TRIFOLIATE ORANGE (*Poncirus trifoliata* Raf.).

Black Rot (*Diplodia natalensis* Pole Evans).
Natal: Durban, 1922 (causing die back of twigs).

TUBEROSE (*Polianthes tuberosa*).

Botrytis cinerea (Pers).
Natal: Hill Crest, 1915.

TURNIPS (*Brassica rapa* L.).

White Rust [*Cystopus candidus* (Pers) Liv.].
Natal: New Hanover, 1917.

Soft Rot (*Bacillus carotovorus* Jones).
Natal: Elandskop, 1922.

VIOLET (*Viola odorata* L.).

Leaf Spot (*Alternaria Violae* Gall. Dorsett).
Transvaal: Roodepoort, 1907.

Leaf Spot (*Cercospora Violae* Sacc.).
Cape Province: Barkly East.
Transvaal: Pretoria, 1916; Germiston, 1918; Marikana, 1917.

Leaf Spot (*Phyllosticta Violae* Desm.).
Transvaal: Zandfontein, 1917.

WALNUT (*Juglans* spp.).

Anthracnose (*Glocosporium epicarpii* Thum.).
Cape Province: Toise River, 1912; Eastpoort, 1917.
Natal: Helpmakaar, 1912.

Blight (*Bacterium Juglandis* Pierce).

Cape Province: Somerset East, 1923; Napier, 1917; Simondium, 1922.

Orange Free State: Clocolan, 1920; Parys, 1920.

Natal: Donnybrook, 1917.

Transvaal: Potchefstroom, 1917; Rosslyn, 1919; Pretoria, 1923.

Crown Gall (*Bacterium tumefaciens* Sm. and Towns).

Cape Province: Toise River, 1912; Cathcart, 1912; Groot Drakenstein, 1913.

Leaf Blight [*Marsonia Juglandis* (Leb.) Sacc.].

Natal: Maritzburg, 1919.

Transvaal: Naboomspruit, 1921.

Leaf Spot (*Cercospora Juglandis* Kell. and Sw.)

Natal: Cantocow, 1916; causing defoliation.

WATER MELON (*Citrullus vulgaris* Schrad).

Anthracnose [*Colletotrichum lagenarium* (Pass.) Sacc.].

Transvaal: Pretoria, 1907.

Leaf Blight (*Macrosporium cucumerinum* E. and E.).

Cape Province: Kraaifontein, 1920.

Powdery Mildew (*Erysiphe cichoracearum* D.C.).

Cape Province: Port Alfred, 1920.

Transvaal: Hatherley, 1923.

Wilt (? *Bacillus tracheiphilus* Erw. Sm.).

Transvaal: Kliptown, 1922.

WATTLE (*Acacia mollissima* Willd.).

Leaf Spot (*Stigmina verruculosa* Syd.).

Natal: Harden Heights, 1911; Winklespruit, 1913.

Mottling.

Stem and branches show darkened patches; later cracks appear in mottled areas through which gum exudes; these may heal, but new tissues often become cracked and exude gum; attributed to physiological disturbance caused by heavy soils and heavy rains following a prolonged drought.

Natal: Hilton Road, 1914; Mid-Illovo, 1914; Ixopo, 1914; Paddock, 1915; Krantzkop, 1920.

WHEAT (*Triticum vulgare* L.).

Black Rust (*Puccinia graminis* Pers).

Transvaal: Boksburg, 1912; Lydenburg, 1914; Pretoria, 1915.

Cape Province: Alexandria, 1915; Bathurst, 1920; Middelburg; Elsenburg.

Loose Smut [*Ustilago tritici* (Pers) Jens.].

Cape Province: Middelburg, Elsenburg.

Powdery Mildew (*Erysiphe graminis* D.C.).

Transvaal: Lydenburg, 1915; Pretoria, 1917; Marikana, 1918.

Cape Province: Modderfontein, 1914; Middelburg.

Flag Smut (*Urocystis tritici*).

Transvaal: Zeerust, 1918.

Cape Province: Elsenburg.

Orange Leaf Rust (*Puccinia triticina* E. and Fr.).

Natal: Cedara, 1911, 1923.

Stinking Smut or **Bunt** (*Tilletia laeris* Kuhn.).

Cape Province: Aliwal North, 1914.

Transvaal: Pretoria, 1917.

Stinking Smut or **Bunt** [*Tilletia triciti* (*Beij*) Wint].

Cape Province: Elsenburg; also reported to be of general occurrence.

Take All (*? Ophiobolus graminis*, Sacc.).

Transvaal: Dullstroom, 1916.

Cape Province: Humansdorp, Uniondale, Middelburg.

Vrot Pootje (*? Fusarium* sp.).

Cape Province: Elsenburg, 1920; Durbanville, 1920, 1922.

WILLOW (*Salix* spp.).

Crown Gall (*Bacterium tumefaciens* Sm. and Towns).

Extremely common on this host.

Gnomonia sp.

Transvaal: Irene, 1912.

BOTANICAL SURVEY OF SOUTH AFRICA

MEMOIR No. 7

THE NATIVE TIMBER TREES OF THE SPRINGBOK FLATS

By Ernest E. Galpin, F.L.S.

To be had from the Librarian, Agricultural Department, Union Buildings

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DIVISION OF BOTANY,
PRETORIA,
11th October, 1924.

SIR,

I have the honour to forward herewith the manuscript of a paper entitled "The Native Timber Trees of the Springbok Flats" (Districts Waterberg and Potgietersrust, Transvaal) by Mr. Ernest E. Galpin, F.L.S., and I have to recommend that it be published as Memoir No. 7 of the Botanical Survey.

The paper embodies valuable information with regard to the timber value of many of our indigenous trees of the open bush country of the Transvaal and which is not readily available to the general public. Mr. Galpin has spared no efforts to verify the information and the facts which he has accumulated, and he has rendered a distinct service to botanical science by depositing in the National Herbarium beautifully preserved material of all the timber trees mentioned.

The manuscript has been submitted to the Chief Conservator of Forests, and its publication has his wholehearted approval.

I have the honour to be,

Sir,

Your obedient Servant,

I. B. POLE EVANS,
Director, Botanical Survey of S.A.

To

THE SECRETARY FOR AGRICULTURE,
DEPARTMENT OF AGRICULTURE,
PRETORIA.

Frontispiece.] [*Photo by Dr. P. A. Wagner. Dec.*, 1923.

ACACIA ALBIDA DEL.
Near Magalakwen Bridge, on farm Blinkwater No. 707.

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The Native Timber Trees of the Springbok Flats.

(Districts Waterberg and Potgietersrust, Transvaal.)

By Ernest E. Galpin, F.L.S.

The following list of local indigenous trees yielding timber has been compiled in connexion with a general botanical survey of the Springbok Flats, in which I am engaged under the direction of Dr. I. B. Pole Evans, C.M.G., Chief of the Division of Botany and Director of the Botanical Survey of the Union, to whom I wish to express my appreciation and thanks for his unfailing courtesy and kindness and for his valuable advice and help and the great encouragement he has given me at all times in undertaking this work.

The botanical names, upon the correctness of which so much of the value of the work depends, have been determined by Dr. E. P. Phillips, M.A., D.Sc., Keeper of the National Herbarium, Pretoria, from actual specimens of the trees dealt with, collected, and forwarded by me to the latter institution, where they are preserved and are available for reference.

I wish to express my thanks to him and his assistants for their valuable services in this connexion and for the great care exercised and trouble taken to ensure accuracy with respect to critical species.

There is little published information available regarding the timber value of many of the indigenous trees in this neighbourhood and of the open forests of the Transvaal in general, a number of which are of considerable value.

Whilst here and there one finds residents possessing a fair knowledge of these timbers, such knowledge is by no means general, and those having it find difficulty in imparting it to others with any certainty from lack of knowledge of the botanical names of the respective trees and the great confusion arising from the number of totally different plants which have been given the same vernacular names. As a general rule, I have found the native names to be far more accurate and reliable.

The vernacular names given in this list are those in local use and do not always agree with those used in other parts of the Union.

Having such a large variety of timbers to select from, the majority are comparatively neglected and the best for local purposes only used, for which the demand is for wagon-wood and for woods that are most resistant to termites, boring beetles, and maggots.

Natives make use of a far greater variety, and many of the older natives possess an intimate knowledge of the timber qualities of various

trees of which the younger ones know very little. With regard to some of the smaller and less valuable timber trees, very little information is available beyond what can be obtained from native sources.

In the deep soils of the Flats, the trees, as a rule, are much larger and better grown than those of the same species growing in the shallower soils of the neighbouring hills, but, as is generally the case with trees growing in open country, they are usually much branched, and with the majority of species it is difficult to get straight lengths beyond seven or eight feet.

The information now presented is derived from personal observation and from what I have been able to gather from both white and native sources during a residence of five years on the Springbok Flats. In this, I have derived much assistance from my son, Mr. E. A. Galpin, who has taken a great interest in my work and been of considerable help to me.

In those cases in which I have been unable to confirm from personal observation any information received, every effort has been made to obtain corroboration from as many sources as possible, and when these conflict, to go carefully into the matter and discard any information given not found to be reliable.

I desire thankfully to acknowledge my obligations to the many friends who have so willingly helped me in the matter, all of whose names I cannot mention here, but wish to pay special tribute to the following gentlemen :—

To W. I. S. Driver, Esq., Sub-Native Commissioner, Nylstroom, who has not only given me much information about the trees growing on the south-western portion of the Flats, but has very kindly revised the native names of the trees and corrected their spelling, with regard to which he is a competent authority.

Mr. Driver has an exceptionally intimate knowledge of the Sesuto language, both spoken and written, in addition to which, during his long residence in the neighbourhood, he has taken an intelligent interest in the native flora and is personally well acquainted with most of the trees themselves and their native names.

To H. T. W. Salusbury, Esq., of the farm Lleweni, Naboomspruit, who has made a life hobby of furniture-making and general joinery, using native timbers exclusively, and during a residence of eighteen years in the Waterberg has obtained a very intimate knowledge of the timber qualities of the great majority of the trees listed, which he has freely placed at my disposal and afforded me much information of great value.

To Messrs. Jerome Dennison and G. W. Dargon, of the farm Klipplaats, Naboomspruit, who for the past twenty years have been engaged in the cutting of timber on various farms in this neighbourhood under contracts for the supply of mine props, wagon-wood, etc., and have also freely given me the benefit of their long experiences and valuable knowledge of the timber qualities of the various trees.

To D. F. Gilfillan, Esq., of Johannesburg and Sunningdale, Koornpunt, who has very kindly collected and forwarded to me many specimens of the trees found along the northern border of the flats, together with all the information locally obtainable regarding them.

E. E. G.

ACACIAS.

Acacias are the dominant trees in all formations excepting the heavy sand veld. As a general rule, the timber of the species having dark-coloured wood is very heavy, hard, strong, and resistant to termites and borers. It does not warp nor twist, but splits easily longitudinally.

On the other hand, that of those species having light-coloured wood does not split and is sometimes very tough and strong, but is liable to attack by borers, and warps and twists badly on drying, unless cut when the sap is down and very carefully seasoned.

Acacia albida, Del. (Galpin, No. 9137).

Aapiesdoring; Mogabo (Sesuto).

This is the well-known Ana tree of the South-West Protectorate, and is widely distributed throughout tropical Africa. It is by far the largest tree in the Waterberg, and attains here a height of 90 feet and a circumference of 15 feet, breast high.

Only found in the north-east corner of the Springbok Flats, on the banks of the Gompies River, just below its confluence with the Strydpoort River. Outside of the area being dealt with there is another fine group, known as "Livingstone's trees," on the alluvial flats near the bridge over the Magalakwin River, in the neighbourhood of Potgietersrust. (Frontispiece.)

The tree is held sacred by the natives, and I have not been able to obtain any local information as to its timber qualities. Dr. Sim, in his "Native Timbers of South Africa," reports: Timber light grey, coarse-grained, fit for fuel only, and not good even for that."

C. J. Andersson, who accompanied Francis Galton in his travels through Damaraland, writes in his "Lake Ngami or Explorations in South-Western Africa," page 45: "The wood of this tree, though straight-grained, close, and weighty, is not considered good for implements of husbandry. I have been assured, however, that when the tree is burned down the quality of the wood is much improved."

Acacia Benthami, Rochbr.

Lekkerruikpeul; Swartsaadpeul; Red Heart; Motse (Sesuto); Nshangwa (Shangaan).

Tree 15 to 25 feet high; stem 12 to 18 inches diameter. Common in the richer sand veld soils, the Thomboti association, and the black turf. Not found in the sour Combretum veld, nor in the red loams.

Wood dark red, very durable, hard, and close-grained; not attacked by either termites or borers. Used for fencing-posts, mine props, dissel-booms, and yoke-skeys.

Makes a very durable fence-post, but even when barked is not so fire-resistant as Sikkelbos (*Dichrostachys*) nor Kaffir Wachteenbietje (*Acacia caffra*), and when the grass is long is liable to be burned by grass fires. The pods are used for making ink and for tanning. (Fig. 1.)

Acacia Burkei, Benth.

Locally known as Knoppiesdoring, but this name more properly applies to *A. pallens*, found in the warmer parts of the Transvaal. Also occasionally

called Aapiesdoring, though this name is more generally applied to *A Galpinii* and leads to confusion.

Sesuto name: Mokhoaripi.

Tree, 40 to 50 feet high, frequently having a fine, straight trunk, 2 to 3 feet in diameter. Found only in the richer sand veld soils, where in places it is found in fair numbers, but is rather local in its distribution.

Wood nearly black, very heavy, very tough, and close-grained. It is very strong, and, contrary to most of the hard-wooded Acacias, works easily and well, and is considered one of the best woods we have for general purposes. Used for tables, chairs, and other furniture; for disselbooms, spokes, and the bed-planks of wagons and for mine props. (Fig. 2.)

Acacia caffra, Willd.

Kaffir Wag'nbietjie; Motholo (Sesuto); Mbenyasehloka (Shangaan).

Tree, 25 to 35 feet high; stem, 12 to 15 inches diameter. Frequent in the richer sand veld soils and in the sour Combretum veld.

Wood nearly black, extremely hard, heavy, and close-grained, with very thin sapwood. Not attacked by either termites or borers. Exceedingly durable in the ground and resistant to grass fires. Next to Sekelbos (*Dichrostachys*) it is the best timber in the Transvaal for fencing-posts and considered fully equal to Sneezewood. It is also sometimes used for spokes and yokes, but is not equal to many of the other woods for this purpose, as it splits easily, is heavy, and is somewhat inclined to be carroty (short-grained). Though by no means general, in some localities the older trees are subject to dry-rot, but sound posts cut remain free from this disease. (Fig. 3.)

Acacia detinens, Burch.

"Haakdoring" Wynruit, Blouhaak. The name Blouhaak is also occasionally applied to *A. hebeclada;* Monyaka-tau (Sesuto).

Small bushy tree, 15 to 20 feet high; stem, 6 to 9 inches diameter. Common in brak ground.

Wood with a small greenish-black heart resembling ebony. Sapwood thick, whitish. Very tough and elastic, does not split, and is unsurpassed for axe and pick handles, for which purpose it is considered equal to hickory. Also used for draaibords in wagons. The heart is termite and borer proof, and the larger stems make excellent fencing-posts. As a rule the trees are much branched and crooked, and stems suitable for fencing-posts are only occasionally met with. (Fig. 4.)

Acacia Galpinii, Burtt-Davy.

Aapiesdoring (this name is also occasionally applied to *A. Burkei* and to *A. albida,* which has led to confusion); Moluha (Sesuto); Mkohokoho, but frequently spoken of simply as Umti-mkulu, meaning the big tree (Shangaan).

With the exception of *Acacia albida,* this is the largest tree found in the Waterberg, attaining a height of 50 to 60 feet and a diameter of 4 feet, breast high. It grows along river banks, and locally is only found along

the Badzynloop River on the western border of the flats. It is also found along the Sand River and other rivers on the south-western border of the Waterberg and adjoining portion of Rustenburg District, and along the Elands River, District Pretoria. Dr. P. A. Wagner informs me that a fine specimen he measured at Wachteenbietjesdraai, on the Rustenburg border, has a stem 16 feet in circumference.

Wood pale brown, with a comparatively small dark-brown heart. It is lighter in colour and a good deal softer than that of *A. Burkei*, though fairly hard, and is reported to be very durable. It is liable to crack unless seasoned. Valuable for wagon-wood and general purposes.

The timber has been used in the railway workshops, Pretoria, and the officer in charge of timber investigations supplies the following information regarding it: "It is used for buffer blocks on ends of trucks, bolster blocks between bogey and carriage; also for framing to a small extent and trolley building. The wood is exceedingly hard to work, heavy, with a light brownish tinge. Although the wood has numerous fairly large pores, the wood surrounding them is of such great density as to account for its weight and difficulty to work."

The native winnowing dishes are made from the inner bark of this tree, which is cut into strips about half an inch wide and plaited into shallow, circular dishes about two feet in diameter. They are very light, strong, and durable. (Figs. 7 and 8.)

Acacia Gerrardi, Benth.

Aapkop. Frequently confused with *A. robusta* and called by the same names, viz., Oudoring or Engelsedoring. The natives also have the same names for these two species, though they recognize the difference, viz., Mouku (Sesuto) and Mongamanzi (Shangaan).

Tree 25 to 30 feet; stem 12 to 15 inches diameter; abundant in sour Combretum veld and occasional in black turf.

Small, dark brown heartwood, with thick white sapwood. Fairly tough and strong, but not durable, the sapwood becoming riddled with borers. Very little used. (Fig. 6.)

Acacia giraffae, Burch.

Kameeldoring; Mpatsaka (Sesuto).

Tree 25 to 30 feet; stem 12 to 15 inches diameter; often long and straight. In light sandy loams and red loams. Abundant at the Potgietersrust end of the Flats, but rare and very local elsewhere.

Wood dark red-brown, very heavy, and very strong, not touched by termites or borers. Used for general wagon-wood and for mine props. (Fig. 9.)

Acacia hebeclada, DC.

Pendoring (this name also applies to *Gymnosporia buxifolia*), also occasionally called Blouhaak, which name is also applied to *A. detinens*; Mohae (Sesuto).

Small bushy tree up to 18 feet high and 12 inches diameter. Common in the Thomboti association (brak ground) and occasional in sandy loams.

Wood dark brown and very hard, but stems much branched and crooked. Only suitable for small work and not used. (Fig. 10.)

Acacia karroo, Hayne.

Sweet Thorn; Doringboom; Moka (Sesuto); Munga (Shangaan).

Tree 20 to 25 feet; stem 12 to 14 inches diameter; common in light sandy loams and red loams, and occasionally in black turf. Wood pale biscuit colour, hard and tough, but grain frequently twisted and very liable to warp on drying and also to attack by borers. Largely used for yoke-skeys.

Grown under favourable conditions, with long straight stems, the grain is not so much twisted, and the poles make excellent and durable disselbooms, provided they are cut when the sap is down and are carefully water-seasoned.

The inner bark strips off easily, is very pliable whilst wet, is strong, and universally used by natives for cordage. When the bark is cut or otherwise injured, it freely exudes a gum which is sweet and edible and useful for confectionery, and also makes an excellent, non-poisonous adhesive. (Fig. 11.)

Acacia lasiopetala, Oliver.

Mokhaba (Sesuto); Inkwakwa (Shangaan).

A large and handsome tree, about 40 feet high; stem about 2 feet in diameter.

Only found along the northern border of the flats, where it occurs in fair numbers in light sandy soil.

The wood is soft and quickly destroyed by boring beetles and termites unless seasoned under water. When thus seasoned for six months, it is stated to be excellent for wagon-wood.

It appears to be increasing on farms where the veld is protected from grass fires. Young trees, up to as much as 10 and 15 feet high, are apt to be destroyed by grass fires owing to their loose, papery bark, which easily catches alight. (Fig. 12.)

Acacia litakunensis, Burch. (= *A. spirocarpoides,* Engl.).

Haak-en-steek; Mushu (Sesuto); Msasana (Shangaan).

Tall flat-topped tree, 30 to 35 feet high; stem 12 to 14 inches diameter; abundant in red loam soils, occasional in the brak Thomboti association, and more rarely in black turf. Not found in sour Combretum veld.

Wood whitish, soft, but tough. Like most of the white-wooded Acacias, it warps on drying, is liable to be riddled by borers, and is not durable unless cut when the sap is down and water-seasoned, when it makes good disselbooms and yokes. (Fig. 13.)

Acacia retinens, Sim.

Swarthaak, Mohotlo (Sesuto). The latter name is also applied to *A. giraffae.*

Tree 30 to 40 feet high; stem 12 to 16 inches diameter. Abundant in the Thomboti association, in brak ground, and occasionally found in red loam soils.

Wood dark red, very hard and heavy, with thin sapwood. Termite and borer proof. Stands wet well and said to be the best timber for lining wells. Is very fire resistant and is the best timber for gate and fencing-posts where something larger than Sikkelbos (*Dichrostachys*) or Kaffir Wachteenbietje (*A. caffra*) is required, though not quite so durable as either of the latter. The older trees are occasionally found affected with dry-rot and any poles cut showing signs of it should be discarded. If sound when cut, the poles remain unaffected for many years. (Fig. 5.)

Acacia robusta, Burch.

Oudoring ; Engelsedoring ; Monku (Sesuto) ; Mongamanzi (Shangaan). All of these names are also given to *A. Gerrardi*, which is also known by the distinctive name " Aapkop."

Tree 20 to 30 feet high ; stem 12 to 15 inches diameter. Frequent in sweet, red loam soils, rare in the brak Thomboti association, and not found in sour Combretum veld, where *A. Gerrardi* takes its place.

Wood biscuit colour, with small, light-brown heart. Does not split and is exceptionally tough. Makes good yokes and is also used for wedges for splitting up the trunks of Thomboti trees (*Spirostachys africanus*), for which purpose it is excellent. Liable to warp and to destruction by borers unless treated as recommended under *A. litakunensis*. Old trees are almost invariably affected with dry rot and riddled by borers and should not be used. (Fig. 14.)

Bolusanthus speciosus, Harms.

Olifantsbos ; Mera (Sesuto).

Tree 30 to 40 feet high ; stem 12 to 15 inches diameter. Only found along the northern border of the flats on limestone hills, where it is not uncommon.

Very strong, durable, hard wood, excellent for general purposes, and much used by natives in the neighbourhood where many trees are pollarded by their cutting.

Has handsome foliage, bears racemes of beautiful violet-blue wistaria-like flowers, and is well worth growing as an ornamental tree. (Fig. 15.)

Boscia rehmanniana, Pest.

Locally known as Witgat, but throughout the Union this is the name for *Boscia albitrunca* ; also occasionally called Wonderboom, which name is also unfortunate since it is generally applied to *Ficus pretoriensis* ; native name Mphipi (Sesuto).

A small and very striking tree, 10 to 15 feet high, having a light-coloured trunk, 12 to 15 inches diameter ; surmounted by a globose mass of dark-green, densely imbricating virgate branches. Abundant in the Thomboti association and other brak soils and occasional in red loam Acacia veld.

Wood very white, hard, and close-grained, but is much twisted, and sound pieces can only be obtained of sufficient size for small articles.

Used by natives for making spoons and stools. (Fig. 16.)

Boscia albitrunca, Gilg and Benedict. (Galpin, No. M. 467).

Motlope; Motlope (Sesuto).

Tree about 15 feet high, having a stem about 10 inches diameter, occurring occasionally in light sandy loams and heavier red loams.

Wood white, hard, and close-grained. Not so much twisted as that of *B. rehmanniana* and generally sounder, but otherwise similar and used by natives for the same purposes.

The roots are stamped, dried, and boiled by natives for coffee, which is also greatly favoured by some of the old resident white farmers. They are also eaten by natives as porridge. (Fig. 17.)

Burkea africana, Hook.

Wilde Sering; Monoto (Sesuto); Mkenge (Shangaan).

Tree 30 to 40 feet high; stem 12 to 15 inches diameter. Abundant in the sand veld, to which it is strictly confined. In certain localities the older trees frequently have trunks hollow in the centre, whilst in others one finds many old trees with their trunks perfectly sound.

One of our most valuable timbers for furniture, wagon-wood, and general purposes, of which good long, straight logs can be obtained.

Mr. H. T. W. Salusbury recognizes three varieties, not distinguishable by either foliage or floral characters, viz.:—

Red Sering.—Bark grey, deeply cut into oval or roundish scales. Wood deep mahongany red, with very thin sapwood, is medium hard, and not attacked by borers. It is softer, less heavy, straighter in the grain, and splits more easily than Yellow Sering. Takes a fine polish, works well, and makes beautiful furniture. (Fig. 18.)

Yellow Sering.—Bark rough, darker in colour, not so deeply cut into scales as that of Red Sering, and the tree usually has a flatter crown. The wood is yellow when sawn and takes a light mahogany finish. It is of medium weight, extremely hard and tough, and so cross-grained that it cannot be split with an axe and cannot be planed, requiring to be finished with a scraper. It, too, makes beautiful furniture, but is more difficult to work than Red Sering. For wagon naves and felloes it is excellent and is most valuable for any purpose where strength, combined with non-liability to split or crack, is required.

The wood is liable to be attacked by borers whilst green.

White Sering.—A smaller tree than either of the other two varieties, not exceeding 10 to 20 feet in height, and rarely having a stem more than 6 inches in diameter. Bark similar to that of Yellow Sering. The wood is whitish-yellow, with an indefinite red heart, and is similar in character to that of Red Sering, but is much attacked by borers, is usually unsound, and seldom straight. Locally, so far as known, it is only found on the hill-sides along the western border of the flats.

The red and yellow varieties are generally recognized as being very distinct, but the white variety appears to be very little known.

Clerodendron glabrum, E. Mey.

Mothlokuthloku (Sesuto).

Tree 15 to 20 feet high; stem about 9 inches diameter. Only attains arborescent size along the northern borders of the flats in sandy loams, and I have no local information as to its timber value.

Dr. T. R. Sim, in his "Native Timbers of South Africa," reports: "Wood white, fairly heavy, hard, and dense; seldom used."

Combretum apiculatum, Sond.

Rooibos; Mogoeleri (Sesuto); Shikukutse (Shangaan).

Tree 15 to 20 feet high; stem 9 to 12 inches diameter. Found only in sour Rooibos veld, where it is abundant.

Wood yellowish-white, with a black heart, which in old trees is sometimes very large. Wood very strong, close-grained, hard, and tough, and is not attacked by either termites or borers. Makes excellent fencing-posts when barked, but they are not so fire-resistant as Sekelbos (*Dichrostachys*) nor Kaffir Wag'nbietjie (*Acacia caffra*). Valuable for mine props. The wood is also used for spokes and is considered the best local wood for charcoal. (Fig. 19.)

Combretum erythrophyllum, Sond. (Galpin, No. M. 642).

Locally called Vaderlandswilg, but this name is elsewhere applied to other species of Combretum; Modubu (Sesuto).

Large tree, 30 to 50 feet high; stem 18 to 24 inches diameter; found along the banks of the Nyl and of the rivers flowing on to the flats from the north.

Wood a distinct yellow, deeper in colour than that of the Vaalbos (*Terminalia sericea*), soft, but tough, and easily worked. Should be cut when the sap is down and water-seasoned, otherwise it is not durable. Timber from it can be obtained in 12 to 14 feet lengths and is useful for rafters and general purposes. The wood is also used for cattle troughs. (Fig. 24.)

Combretum Gueinzii, Sond.

Mogoeletshane (Sesuto).

Tree 15 to 20 feet high; stem 8 to 12 inches diameter. Occasional in the sour Rooibos veld and in sand veld. Wood very yellow, is soft and has a coarse, much-interlaced grain. Rots easily and, though tough whilst green, is brittle when dry. Timber looked upon as useless and not used. (Fig. 20.)

Combretum imberbe, Wawra., var. **Petersii,** Engl. and Diels.

Hardekool; Leadwood.

Tree 30 to 40 feet high; stem 18 to 36 inches diameter. In this locality it is only known to occur along the northern and south-western borders of the flats.

Wood very dark brown, with thin sapwood. Exceedingly hard, heavy, strong, and durable, and does not split. Is not attacked by termites or borers and is excellent for fencing-posts and mine props, though it seems a pity to use so valuable a wood for these purposes. Said to have a beautiful grain and to make handsome furniture, but very heavy. The General Manager of the Premier Diamond Mine advises that he has used the wood for machinery bearings in places where it was not subjected to any severe strain with satisfactory results, but that it could not be utilized for high speed shafting nor for slow speeds where a heavy load was involved.

Professor Lawson, in " Flora of Tropical Africa," Vol. 11, states that the wood is described as being exactly like that of the *lignum vitae*.

Dr. Sim, in his " Forest Flora of Portuguese East Africa," states it has rather brittle and most durable timber, so hard that before the advent of iron hoes, this was used instead. (Fig. 21.)

Combretum rhodesiacum, Bkr. f.

Kierieklapper ; Steelboom ; Mokata (Sesuto) ; Mpotsa (Shangaan).

Tree 12 to 20 feet ; stem 6 to 9 inches diameter ; frequent in red loam soils ; occasional in Rooibos veld, light sandy loams, and the brak Thomboti association.

Wood brownish, with darker streaks, not attacked by termites nor borers. Exceedingly hard and tough and very strong. Used for pick-axe handles, spokes, etc. Stems are usually crooked and straight lengths suitable for larger articles are difficult to obtain. (Fig. 22.)

Combretum Zeyheri, Sond.

Raasbos ; Nicholas Klapper ; Moluba (Sesuto) ; Mphuba (Shangaan).

Tree 20 to 25 feet high ; stem 9 to 12 inches diameter. Frequent in sand veld and Rooibos veld.

Wood yellowish-white, oxidizing to a bluish-grey on exposure. Rather unpleasantly scented whilst green and liable to be attacked by borers. Becomes very hard and tough when dry and makes excellent yokes, superior to Stinkwood. Works easily and well, and is a good all-round timber. (Fig. 23.)

Cussonia natalensis, Sond.

Nooisboom ; Mafakulu (Sesuto) ; Mosenje (Shangaan).

Tree 20 to 25 feet ; stem 14 to 18 inches diameter ; occasional in the richer sand veld soils.

Wood white, very soft, and light, pithy in the centre. Used by natives for making drums, the pithy centre being scooped out. Also used by them for carving into bowls and dishes. Makes good brake blocks. (Fig. 25.)

Cussonia spicata, Thunb.

Nooisboom.

Tree 15 feet ; stem 12 to 15 inches diameter. Occurs in the richer sand veld soils, but is rare in this area.

Wood very light, soft, and coarse-grained. Used for brake blocks.

Dr. T. R. Sim, in his " Native Timbers of South Africa," states : " Also used as a basal block in which the pole of a swing gate turns, for which purpose it lasts fairly well."

Dichrostachys nutans, Benth.

Sekelbos ; Moselesele (Sesuto) ; Ndenge (Shangaan).

Tree 15 to 20 feet ; stem 9 to 12 inches diameter. Abundant in sweet, light sandy loams, and less frequently in the richer red loams. Not found in Rooibos veld. Wood dark brown, extremely hard and strong, and very durable. Has very little sapwood and is termite and borer proof. It is very resistant to grass fires, and is the best wood in the Transvaal for fencing-posts, being superior to Sneezewood and practically imperishable. It is

also one of the best woods for charcoal, excepting for smithy work, for which it is too explosive. (Fig. 26.)

Dombeya rotundifolia, Harv.

Drolpeer; occasionally also called Dikbas, but this name is more usually applied to *Lannea discolor*; Mokhuba (Sesuto); Shilubari (Shangaan).

Tree 15 to 20 feet; stem 8 to 12 inches diameter. Frequent in the richer sand veld soils and in Rooibos veld.

Wood bluish-grey, heavy, strong, and exceedingly tough and cross-grained. Stems, as a rule, are rather crooked, and straight pieces are difficult to get over 6 feet long. Used for naves, spokes, felloes, yokes, mine props, and general work. Makes the most durable yoke-skeys of any wood known. A first-class timber and excellent for any purpose for which a wood is required that does not split and has great strength. Is one of the best wagon-woods we have. (Fig. 27.)

Erythrina caffra, Thunb.

Kaffirboom; Mokungoane (Sesuto); Mbala (Shangaan).

Tree 15 to 20 feet high; stem 9 to 12 inches diameter. Only reaches timber size on the hill-sides bordering the flats.

Wood white, very light, and spongy. Only used for brake blocks.

Euclea lanceolata, E. Mey.

Gwarri; Mokueretani (Sesuto); Nhlangula (Shangaan).

Tree 12 to 15 feet high; stem about 6 inches diameter. Usually shrubby, but occasionally reaches timber size. Abundant in the brak Thomboti association and frequent in bush clumps on red loam soils.

Wood dark brown, hard, and close-grained. Used by natives for stools and yoke-skeys. The brushwood from shrubby plants is very useful for the sides of rough cattle sheds and shelter screens. It lasts well and is sufficiently rainproof without plastering or daubing.

Faurea saligna, Harv.

Transvaal Beukehout; Monyela (Sesuto); Ngwamutsumba (Shangaan).

Tree 25 to 35 feet high; stem 12 to 15 inches diameter. Very local on the flats, where small groups are occasionally found on sand-veld ridges. Abundant in the hilly country along the western border, where, in favourable situations, it sometimes attains a height of 50 feet.

The wood is beautifully reticulated, has distinct medullary rays, and varies from pale biscuit colour to red. It is strong and durable, of medium weight, is not attacked by borers, does not warp nor shrink, and can be worked green. It is, however, somewhat carroty (short-grained), and should not be used where much lateral strength is required. Mr. H. T. W. Salusbury states that a peculiarity is that the grain has a slight twist, amounting to about half a turn in six feet, which almost invariably results in a central windshake.

It is the easiest of the native woods to work, takes a good finish, and is very valuable for furniture, doors and windows and their frames, and general joinery. In places where it is abundant it is frequently used for

fencing-posts, and is said to stand fairly well, but is not quite termite proof and not to be compared for this purpose with either Sekelbos (*Dichrostachys*) or Kaffir Wag'nbietjie (*Acacia caffra*). It is also said to stand well in water and wet places. (Fig 28.)

Mr. H. T. W. Salusbury informs me that the wood makes a blood-red dye when put in water, or a brilliant yellow if lime be added to the water. He recognizes three distinct varieties of Beukehout timber, not distinguishable in the living tree, viz. :—

Red Beukehout.—Colour a distinct red. Has a fair amount of white sapwood, and is the softest and easiest to work of the three varieties. Makes beautiful furniture.

Yellow Beukehout.—Colour almost yellowish-pink, with dark brown streaks running through the grain. Has a fair amount of white sapwood. Is somewhat harder and more difficult to work than Red Beukehout. Is beautifully figured and makes the handsomest furniture of the three varieties.

White Beukehout.—This variety is comparatively rare compared with the others. Colour pale biscuit colour. Has very little sapwood, and is very much harder and more difficult to work than the other varieties. It is also duller in colour and not nearly so decorative for furniture.

Ficus spp.

Wild Fig Trees; Sesuto: Mphayi for *Ficus capensis* and Mounio for the small-fruited species generally. (Fig. 29.)

Ficus capensis, Thunb., and several other arborescent species of *Ficus* bearing small fruits are found in the light sandy soils on the flats and on the slopes along its borders, and I have not been able to ascertain from which species the timber I have seen has been cut, but all are reported to produce timber of similar character.

Wood whitish, very light, soft, woolly, and difficult to saw. Said to be both durable and tough and better than that of Morula (*Sclerocarya*). It warps badly and is difficult to season. Useful for the bed-planks of wagons, but must be fixed whilst green to prevent warping, and for rough work generally. (Fig. 30.)

Fluggia microcarpa, Blume. (Galpin, No. M. 699).

Shangaume (Sesuto); Tshangaume; Nsangasa (Shangaan).

Shrub or small tree about 12 feet high; stem about 3 inches in diameter; occasional in sand veld.

Wood white and exceedingly strong, tough, and elastic.

Used by natives for whipsticks and other purposes where a thin but strong wood is required.

Gymnosporia buxifolia, Linn.

Pendoring (this name is also applied to *Acacia hebeclada*); Mopasu (Sesuto); Sihlangwa (Shangaan).

Small tree, 10 to 15 feet high; stem about 6 inches diameter; frequent in red loam soils.

Wood white, close-grained, and heavy; not obtainable large enough for any but small articles. Used by natives for spoons and rough stools. (Fig. 31.)

Heeria paniculosa, O. Ktze.

Resin Bush; Rapuis (a corruption of Harpuis = resin); "Respies," quoted by Burtt-Davy as the local name, is evidently intended for "Rapuis," but the name has not been properly caught; Monuku (Sesuto).

A small bushy tree, about 15 feet high, occasional in Rooibos veld.

Wood reddish-brown, fine-grained, and soft, similar in appearance to pencil cedar. Very brittle and of very poor quality. Not used.

Lannea discolor, Engl.

Bakhout; Dikbas (this name is also occasionally applied to *Dombeya rotundifolia*, but more frequently to *Lannea discolor*); Mokhokhothoane (Sesuto); Shimopyani (Shangaan).

Tree 15 to 30 feet high; stem 12 to 18 inches diameter; frequent in sand veld. Usually of small size on the flats, but on the lower hill-slopes along the western boundary trees up to 30 feet high are frequent.

Wood white, very light, close and evenly grained. Very soft and easy to work whilst green. Shrinks and cracks badly on drying unless water-seasoned, but if cut when the sap is down and water-seasoned makes a very valuable timber. It then becomes tough and hard, works well, does not split nor crack and should be valuable for pattern-making and turner's work. Used by natives for stamp blocks, dishes, and spoons.

I saw a piece of it hollowed into a pipe of 4 inches internal diameter, with walls about half an inch thick, made to use as a pump cylinder. It was very strong and answered its purpose as well as metal piping. (Fig. 32.)

Mimusops Zeyheri, Sond.

Moepel; Rooi Melkhout; Moupuhu (Sesuto).

Tree 15 to 30 feet high; stem 12 to 24 inches diameter. In sand veld. Rather rare and usually of small size on the flats, but frequent on the hill-slopes surrounding them.

Wood pink whilst green, but dries to a biscuit colour. Medium hard, fairly light, grain wavy and rather short. A very useful timber which works very easily, ranking next to Beukehout (*Faurea saligna*) in this respect. Used for yokes, felloes, naves, and general purposes not requiring great strength.

There is some irritant in the green wood which is apt to cause sneezing when working it.

The fruit is edible and pleasant tasted. (Fig. 33.)

Ochna pulchra, Hook.

Seerbos; Seermaak; Mopha (Sesuto); Monyelenyela (Sesuto); Ntatasani (Shangaan).

Small tree, 12 to 15 feet high; stem 6 to 8 inches diameter; frequent in the sand veld. Wood light red, soft, and short-grained. Snaps and cracks easily and is not used. (Fig. 34.)

Olea verrucosa, Link.

Wild Olive; Olyfhout; Motlhoari (Sesuto).

Tree 15 to 20 feet high; stem 12 to 30 inches diameter. Occasional in the richer sand veld and light sandy loams.

Wood yellowish-brown, with dark streaks, pleasantly scented when green. Very heavy, close-grained, and strong. Resistant to termites and borers. Takes a good polish and makes beautiful furniture. Saws well, particularly when green, but is very difficult to work with an edged tool. Can be readily split longitudinally, but not radially.

Used also for spokes, yoke-skeys, knobkerries, and any purpose where great strength is required. (Fig. 35.)

Pappea fulva, Conrath.

Noupitjie; Morobaliepe (Sesuto); Sikwakwashe (Shangaan).

Tree 15 to 20 feet high; stem 9 to 12 inches diameter. Occasional in Rooibos veld and red loam soils, but large trees are somewhat rare.

Wood brownish, very close and even grained, and very hard. The native name for it, "Morobaliepe," is descriptive and means: "Breaks the axe."

Works readily and is a first-class timber. Used for yokes and skeys and general wagon-wood. (Fig. 36.)

Peltophorum africanum, Sond.

Locally known as Kajatehout, but this name is more widely applied to *Pterocarpus erinaceus,* a common tree in the low veld; occasionally called Huilbos or Huilboerboon, but these names are more properly applied to *Schotia brachypetala* (*q.v.*); Mosetlha (Sesuto); Ntsetse (Shangaan).

Tree 25 to 35 feet; stem 12 to 24 inches diameter. Abundant in the sand veld, and occasional in the Rooibos, red loam, and Thomboti associations.

One of our most valuable and largely used timbers. Mr. H. T. W. Salusbury recognizes two varieties, very different in the quality of their timbers, but indistinguishable in the living tree, viz., Wit Kajatehout and Rooi Kajatehout.

Wit Kajatehout.—Wood biscuit-white, with a small, indefinite, red heart. It is of medium weight, remarkably cross-grained, wavy, extremely tough, but not hard, and cannot be split with an axe. Unsurpassed for naves and felloes and very valuable for any purpose where a non-splitting wood of medium hardness is required. It is rather tough to saw, but otherwise works easily and planes well.

Rooi Kajatehout.—Wood dark mahogany colour, of medium weight and hardness. Works easily and well, takes a good polish, and make beautiful furniture. The grain is somewhat short and it is not too good for wagon work.

The wood of both varieties requires to be seasoned to prevent it from being attacked by a boring maggot, which makes oval holes, and must be painted for outdoor work. The living trees are sometimes rotten in the centre. Natives use the timber for making vatjes and milk buckets and use decoction of the bark as a remedy for worms (Fig. 37.)

Rhamnus Zeyheri, Sond.

Red Ivory; Rooihout; Mokoyhi (Sesuto); Sinyiana (Shangaan).

Bushy tree, 15 to 20 feet high; stem 9 to 12 inches diameter. Occasional in the richer sand veld and in Rooibos Veld.

Wood pink, turning a remarkably bright red on drying, but darkens with oiling. It is heavy, very close-grained, hard, and strong. The grain is similar to that of boxwood, and it might possibly do as a substitute. It takes a beautiful polish and should be valuable for turners' work. It is too gaudy in colour for furniture, but might be used with good effect for beading and inlaying.

It is excellent for spokes and any work requiring great strength. It is also used for yokes, felloes, and knobkerries, but it seems a pity that so valuable and not too abundant a wood should be used for these purposes.

The tree bears an abundance of small fruits which are edible and delicious.

In Spelonken, where these trees grow in profusion, and their drupes are larger and sweeter, besides the ripe fruit which is eaten at once, the natives collect and store the surplus in their grain-storing baskets (sesecos), where they form into a solid, brown, sugary mass. This is greatly prized by them as a delicacy or condiment, and is also much favoured as a concentrated ration when going on a long journey.

The drupes are also sometimes stoned and dried in the sun and kept in store for stamping and mixing with mealie-meal porridge. (Fig. 38.)

Rhus incana, Mill.

*Taaibos; Moholethi (Sesuto); Mbulula makutla (Shangaan).

Small shrubby tree, 12 to 15 feet high; stem 6 inches diameter. Common in the **Thomboti** association and occasional in Rooibos veld, red loam, and black turf.

Wood red-brown, very cross-grained, tough, and elastic. This and *Acacia detinens* are looked upon as being the two best woods in the Transvaal for axe handles and similar purposes, and are considered equal to hickory. The wood is too small for larger purposes.

Rhus lancea, Linn.

Kareeboom (in the Cape Province this name is applied to *Rhus viminalis* and allied species); Moshilabela (Sesuto); Moselavela (Shangaan).

Tree 15 to 18 feet high; stem 9 to 15 inches diameter. Frequent in the richer sand veld and occasional in other associations. It grows particularly well in asgrond (black turf heavily mixed with lime), where it frequently reaches a large size.

Wood dark red, medium weight, of fair strength, straight-grained, and rather splintery. Works well and takes a beautiful polish. Used for yokes, spokes, and other wagon wood. The trees are usually much branched, big trees are often hollow, and it is difficult to get straight pieces of fair length. (Fig. 39.)

* The name "Taaibos" is also applied to other species of *Rhus*.

Rhus Gueinzii, Sond. (Galpin, No. M. 693).

Bastard Karee; Mphapashane (Sesuto). This name is also applied by them to *Rhus* n. sp. (Galpin, M. 64, *q.v.*).

Tree about 15 feet high; stem 9 to 12 inches diameter. Frequent in sand veld. Very similar in appearance to *R. lancea* and often confused locally with it. It differs in the leaflets being somewhat broader and having serrated margins, whilst those of *R. lancea* are quite smooth. It is also more straggly and crooked in growth. The timber is said by Mr. H. T. W. Salusbury and others to be of poor quality, twisted in grain, greatly inferior to that of *R. lancea*, and of very little value.

Rhus n. sp. (Galpin, No. M. 64).

Karee; Mphapashane (Sesuto).

Small shrubby tree, 12 feet high; stem, 4 to 6 inches diameter. Abundant in red loam soils.

Wood red and fairly tough. Used occasionally for pick handles, but not nearly so good as that of *Rhus incana*.

Salacia (?) **transvaalensis,** Burtt-Davy (Galpin, No. M. 470).

Lepelhout; Oupitjie; Monamani (Sesuto); Nkuba Tsebi (Shangaan).

Large tree, 40 to 60 feet high; stem 2 to 3 feet diameter. Frequent in the brak Thomboti association and occasional in red loam soils.

Wood whitish-pink, cross-grained, and of medium weight and hardness. Used by natives for cattle troughs, spoons, ladles, tobacco pipes, etc., and is well suited for turner's work. It is somewhat short-grained and too brittle for wagon-wood and not durable for mine props. (Fig. 41.)

Schotia brachypetala, Sond., var. **pubescens,** Burtt-Davy (No. 9135).

Boerboon. (This name is also applied to other species of *Schotia* not found in this neighbourhood.) Also called Huilbos or Huilboerboon, owing to a viscid secretion which exudes and drops from the flowers.

Tree 20 to 25 feet high; stem 12 to 15 inches diameter. Only found along the northern border of the flats. Reported to be an excellent wagon-wood and in great demand for wagon beams.

Dr. T. R. Sim, in his "Native Timbers of South Africa," states that it has "a pinky-grey sapwood of fair density, and a small, but hard, distinctly separated, dark walnut or almost black heartwood. Surface very good and takes varnish well. A good high-class furniture timber, of which, however, the available quantity is small." (Fig. 42.)

Sclerocarya caffra, Sond.

Morula; Mokanu (Sesuto); Nkanyi (Shangaan).

A large tree, 30 to 40 feet high, usually having a good straight stem, 2 to 3 feet in diameter. Frequent in Rooibos veld and occasional in light sandy loams.

Wood white, drying to a pinkish colour. Of light weight, soft, coarse-grained, and woolly to saw. Warps badly and requires very careful seasoning, and is very liable to be attacked by borers. Excellent for cattle troughs and useful for rough shelving and tables and other rough work.

Used by natives for stamp blocks, troughs, and dishes.

The fruit has great commercial possibilities for jam-making. It is abundant and is easily gathered since it falls to the ground, just before ripe, in the best condition for the purpose. A delicious jelly, quite equal to any on the market, of fine flavour and appearance, is easily and quickly made, as the pulp jellies freely and peeling is unnecessary; all that is required being to cut a slice off each side of the fruit to allow the water to penetrate, boil the whole, and strain through muslin. The residual pulp can then be turned into a good jam, the skins and stones being got rid of by passing through a colander. Both jelly and jam are thus made from the same fruit. The credit for this discovery and the method of manufacture belongs to Mrs. W. H. L. Dearlove, of Gruisfontein, Naboomspruit. (Fig. 43.)

Scolopia Mundtii, Szyszy., var. **Engleri,** Phillips.

Red Pear; Mothlono (Sesuto name for the spine-bearing form); Sepato (Sesuto for the spineless form); Mombula (Shangaan for both forms).

Tree 20 to 25 feet high; stem 9 to 12 inches diameter; bark smooth, buff colour. Very variable both as to foliage and spines. Some trees bear strong, straight spines, sometimes 6 inches in length, whilst others are quite spineless. A somewhat rare tree, occasionally found in the Thomboti, the sand veld, and the basaltic loam associations. Its timber does not appear to be used locally, and very little is known regarding it. Natives report it to be soft and white and susceptible to attack by borers, but as they do not use it their information is not to be relied on. It is a well-known tree in the Cape Province, and Dr. Sim states that it is sometimes 3 to 4 feet in diameter and 60 to 80 feet high. He further reports: "Wood dark grey, hard, heavy, and close-grained; much used by wagonmakers, especially for felloes; it polishes well and might be used in furniture-making." (Fig. 44.)

Securidaca longipedunculata, Fres.

Krinkhout; Tree Violet; Maaba (Sesuto); Mondlandlovu (Shangaan).

Wood pale bluff, spongy and soft, and approaching cork in lightness when dry. On cross section it shows numerous circular rings of more open and coarser fibres scattered over it, about half an inch apart. The wood is not used by natives or others, and is generally considered to be of little value. The bark of this tree affords the Buaza fibre of Zambeziland. ("Flora of Tropical Africa," Oliver.)

The trees bear a great profusion of pretty purplish-pink flowers, which perfume the neighbourhood with a delightful, violet-like scent. (Fig. 45.)

Spirostachys africanus, Sond.

Thomboti; Morekure (Sesuto); Tshopfori (Shangaan).

A fine tree, 25 to 35 feet high, with a good, straight trunk, 18 to 24 inches diameter. Abundant in the brak Thomboti association on the right bank of the Nyl and in brak hollows generally. Occasionally also found in red loam soil, sand veld, and Rooiboos veld.

Wood dark brown, with a beautiful grain and satin-like lustre, but becoming quite black with oiling and age. Sapwood creamy white, very thick in young trees. The wood is pleasantly scented, but loses its scent on exposure in our dry climate. It is very heavy, close-grained, very strong and very durable, untouched by termites or borers.

Used for furniture, but chairs made of it are very heavy to move about, otherwise it makes excellent furniture. It is also used for rafters and occasionally for disselbooms, but splits very easily and is liable to split at the bolt-hole. As uprights for sheds, etc., and for cattle races and such like, where extra tall and strong fencing is required, it is most useful. Large-size trunks are almost invariably hollow in the centre, but can easily be split up with wedges into, say, four poles of great strength. The wood is very hard and difficult to saw by hand. It is not used for ordinary fencing, the poles being liable to be burned in grass fires.

The sap is extremely caustic, and great care must be taken not to get any into the eyes and to wash your hands after working with green wood. Should you as much as rub your eyes with your fingers after handling the latter it will cause intense pain in them for hours. (Fig. 46.)

Strychnos pungens, Solered.

Botter Klapper; Wild Orange; Mokhoaha (Sesuto); Nkwakwa (Shangaan). (This name is also applied to *Acacia lasiopetala*.)

Tree 15 to 20 feet high; stem 6 to 9 inches diameter. Common in heavy sand veld.

Wood white, soft, and short-grained. The wood is brittle when dry and is not used.

The fruit is eaten by natives, but is inferior to that of *S. schulmanniana* and *S. spinosa* (a shrubby species growing in the warmer parts of the Transvaal) and is not tasty. (Fig. 47.)

Strychnos schumanniana, Gilg.

Suur Klapper; Mohloane (Sesuto); Mhlala (Shangaan).

Tree 15 to 20 feet; stem 6 to 9 inches diameter. Frequent in heavy sand veld.

Wood is white, soft, and tough. Makes good yoke-skeys. It has a very thick cork-like bark, resembling that of the cork oak in external appearance.

The fruit is edible and pleasant tasting. When not found ripe on the tree, it is buried to ripen. (Fig. 48.)

Terminalia sericea, Burch.

Vaalbos or Bos Vaalbos; Mohonono (Sesuto); Nkonona (Shangaan).

Tree 30 to 40 feet high; stem 9 to 15 inches diameter. In this area it is strictly confined to the sand veld, where it is abundant and increasing rapidly. Wood canary-yellow, close-grained, very strong, and of good quality, but too difficult to work for general purposes. Excellent for yokes and mine props and useful for fencing droppers, but not for fence-posts, as it does not stand well in the ground. Used by natives for making stools. (Fig. 49.)

Vitex sp. (Galpin No. M. 282).

Pypsteel; Mokoele (Sesuto); Manohani (Shangaan); closely related to *V. reflexa*, Pearson, and probably a new species.

Tree 25 to 30 feet; stem 9 to 12 inches diameter. Abundant and increasing in the sand veld, to which it is strictly confined.

Wood yellowish-grey, of medium hardness and weight. Grain straight and, though somewhat short, is of fair strength. Works easily, takes a good finish, and is not attacked by termites after it is properly seasoned. Owing to the many stronger timbers available, it is little used locally, but should be useful for general purposes. Used by natives for stools. The young twigs have hollow stems and are used as stems for tobacco pipes, hence the local name "Pypsteel." (Fig. 50.)

Vitex Poara, Corbishley.

Stinkbossie; Mphuru (Sesuto).

Shrubby tree, 12 feet high; stem about 6 inches diameter. Occasional in sand veld on the south-western border of the flats.

Timber reported to be of no value.

Fruit edible, black.

Zizyphus mucronata, Willd.

Blinkblaar Wag'nbietjie; Mokhalo (Sesuto); Mpasamhala (Shangaan).

Tree 15 to 20 feet; stem 9 to 24 inches. Frequent in sand veld, red loam, and Thomboti associations, and occasionally in black turf. Wood pinkish-white, very light, of medium strength, tough, and elastic; grain twisted. Warps badly and is not very durable. Used for yokes, felloes, and naves where better wood is not available. The young saplings are used for whipsticks. (Fig. 51.)

VERNACULAR NAMES WITH BOTANICAL EQUIVALENTS.

Aapiesdoring	*Acacia albida.*
Aapiesdoring	*Acacia Burkei.*
Aapiesdoring	*Acacia Galpinii.*
Aapkop	*Acacia Gerrardi.*
Bakhout	*Lannea discolor.*
Bastard Morula	*Lannea discolor.*
Beukehout	*Faurea saligna.*
Blinkblaar Wag'nbietjie	*Zizyphus mucronata.*
Blouhaak	*Acacia detinens.*
Blouhaak	*Acacia hebeclada.*
Boerboon	*Schotia brachypetala.*
Bosvaalbos	*Terminalia sericea.*
Botter Klapper	*Strychnos pungens.*
Dikbas	*Lannea discolor.*
Doringboom	*Acacia karroo.*
Drolpeer	*Dombeya rotundifolia.*
Engelsedoring	*Acacia Gerrardi.*
Engelsedoring	*Acacia robusta.*
Gwarri	*Euclea lanceolata.*
Haakdoring	*Acacia detinens.*

Haakensteek	*Acacia litakunensis.*
Hardekool	*Combretum imberbe.*
Harpuis	*Heeria paniculosa.*
Huilboerboon	*Peltophorum africanum.*
Huilboerboon	*Schotia brachypetala.*
Huilbos	*Peltophorum africanum.*
Huilbos	*Schotia brachypetala.*
Kaffirboom	*Erythrina caffra.*
Kaffir Wag'nbietjie	*Acacia caffra.*
Kajatehout	*Peltophorum africanum.*
Kajatehout	*Pterocarpus erinaceus.*
Kameeldoring	*Acacia Giraffae.*
Karaa	*Rhus.* n. sp. = Galpin, M. 64
Kareeboom	*Rhus lancea.*
Kierie Klapper	*Combretum rhodesiacum.*
Kierie Klapper	*Combretum Zeyheri.*
Klapper	A general name for all species of *Combretum* and *Strychnos.*
Knoppiesdoring	*Acacia Burkei.*
Knoppiesdoring	*Acacia pallens.*
Krinkhout	*Securidaca longipedunculata.*
Leadwood	*Combretum imberbe.*
Lepelhout	*Salacia* (?) *transvaalensis.*
Maaba	*Securidaca longipedunculata*
Mafakulu	*Cussonia natalensis*
Manohani	*Vitex*, sp. = Galpin, M. 282.
Mbala	*Erythrina caffra.*
Mbenyasehloka	*Acacia caffra.*
Mbulula Makutla	*Rhus incana.*
Mera	*Bolusanthus speciosus.*
Mhala	*Strychnos schulmanniana.*
Midlandhlovu	*Securidaca longipedunculata.*
Mkenge	*Burkea africana.*
Mkohokoho	*Acacia Galpinii.*
Modubu	*Combretum erythrophyllum.*
Moepel	*Mimusops Zeyheri.*
Mogabo	*Acacia albida.*
Mogoeleri	*Combretum apiculatum.*
Mogoeletshane	*Combretum Guenzii.*
Moka	*Acacia karroo.*
Mokanu	*Sclerocarya caffra.*
Mokata	*Combretum rhodesiacum.*
Mokhaba	*Acacia lasiopetala.*
Mokhalo	*Zizyphus mucronata.*
Mokhoaha	*Strychnos pungens.*
Mokhoaripi	*Acacia Burkei.*
Mokhokhothoane	*Lannea discolor.*
Mokhuba	*Dombeya rotundifolia.*
Mokoele	*Vitex* sp. = Galpin, M. 282.
Mokoyhi	*Rhamnus Zeyheri.*
Mokueretani	*Euclea lanceolata.*
Mokungoane	*Erythrina caffra.*
Moluba	*Combretum Zeyheri.*
Moluha	*Acacia Galpinii.*
Mombula	*Scolopia Mundtii.*
Monamani	*Salacia* (?) *transvaalensis.*
Mongamanzi	*Acacia robusta.*
Mongamanzi	*Acacia Gerrardi.*
Monoto	*Burkea africana.*
Monuku	*Heeria paniculosa.*
Monyaka-tau	*Acacia detinens.*
Monycla	*Faurea saligna.*
Monyelenyela	*Ochna pulchra.*
Mopasu	*Gymnosporia buxifolia.*
Mopha	*Ochna pulchra.*
Morekure	*Spirostachys africanus.*
Morobaliepe	*Pappea fulva.*

Morula	*Sclerocarya caffra.*
Morula, Bastard	*Lannea discolor.*
Moschavela	*Rhus lancea.*
Moselesele	*Dichrostachys nutans.*
Mosenjo	*Cussonia natalensis.*
Mosetlha	*Peltophorum africanum.*
Moshilabela	*Rhus lancea.*
Mothlokothloku	*Clerodendron glabrum.*
Mothlono	*Scolopia Mundtii.*
Motholo	*Acacia caffra.*
Motlhoari	*Olea verrucosa.*
Motlope	*Boscia albitrunca.*
Motse	*Acacia Benthami.*
Mouku	*Acacia robusta.*
Mouku	*Acacia Gerrardi.*
Moumo	*Ficus* spp. (small fruited species)
Moupulu	*Mimusops Zeyheri.*
Mpasamhala	*Zizyphus mucronata.*
Mpatsaka	*Acacia Giraffae.*
Mphapashane	*Rhus* n. sp. = Galpin, M. 64.
Mphapashane	*Rhus Gueinzii.*
Mphayi	*Ficus capensis.*
Mphipi	*Boscia rehmanniana.*
Mphuba	*Combretum Zeyheri.*
Mphuru	*Vitex Poara.*
Mp t-a	*Combretum rhodesiacum.*
Msasana	*Acacia litakunensis.*
Munga	*Acacia karroo.*
Mushu	*Acacia litakunensis.*
Ndenge	*Dichrostachys nutans.*
Ngwanutsumba	*Faurea saligna.*
Nhlangula	*Euclea lanceolata.*
Nicholas Klapper	*Combretum Zeyheri.*
Nkanyi	*Sclerocarya caffra.*
Nkayi	A general name for all species of *Acacia* having hooked spines.
Nkonona	*Terminalia sericea.*
Nkuba-tsebi	*Salacia* (?) *transvaalensis.*
Nkwakwa	*Strychnos pungens.*
Nkwakwa	*Acacia lasiopetala.*
Nooisboom	*Cussonia* spp.
Noupitjie	*Tappea fulva.*
Nsangasa	*Fluggia microcarpa.*
Nshangwa	*Acacia Benthami.*
Ntatasani	*Ochna pulchra.*
Ntsetse	*Peltophorum africanum.*
Olifantsbos	*Bolusanthus speciosus.*
Olive, Wild	*Olea verrucosa.*
Olyfhout	*Olea verrucosa.*
Orange, Kaffir or Wild	*Strychnos* spp.
Oudoring	*Acacia robusta.*
Oudoring	*Acacia Gerrardi.*
Oupitjie	*Salacia* (?) *transvaalensis.*
Pendoring	*Gymnosporia buxifolia.*
Pendoring	*Acacia hebeclada.*
Pypsteel	*Vitex* sp. = Galpin, M. 282.
Raasbos	*Combretum Zeyheri.*
Rapuis	*Heeria paniculosa.*
Red Heart	*Acacia Benthami*
Red Ivory	*Rhamnus Zeyheri.*
Red Pear	*Scolopia Mundtii.*
Resin Bush	*Heeria paniculosa.*
Rooibos	*Combretum apiculatum.*
Rooihout	*Rhamnus Zeyheri.*
Rooi Melkhout	*Mimusops Zeyheri.*
Seerbos	*Ochna pulchra.*
Seermaak	*Ochna pulchra.*
Sepato	*Scolopia Mundtii.*

Sering, Wilde	*Burkea africana.*
Shangaume	*Fluggia microcarpa.*
Shikukutse	*Combretum apiculatum.*
Shikwakwashe	*Pappea fulva.*
Shilubari	*Dombeya rotundifolia.*
Shimopyani	*Lannea discolor.*
Sihlangwa	*Gymnosporia buxifolia.*
Sekelbos	*Dichrostachys nutans.*
Sinyiana	*Rhamnus Zeyheri.*
Steelboom	*Combretum rhodesiacum.*
Stinkbossie	*Vitex Poara.*
Suur Klapper	*Strychnos schulmanniana.*
Swarthaak	*Acacia dulcis.*
Swartsaadpeul	*Acacia Benthami.*
Sweet Thorn	*Acacia karroo.*
Taaibos	*Rhus* spp.
Thomboti	*Spirostachys africanus.*
Tree Violet	*Securidaca longipedunculata.*
Tshangaume	*Fluggia microcarpa.*
Tshopfori	*Spirostachys africanus.*
Umti-mkulu	*Acacia Galpinii.*
Vaalbos	*Terminalia sericea.*
Vaderlandswilg	*Combretum erythrophyllum.*
Vyndoring	*Acacia Natalitia*, var. *stolonifera.*
Vyndoring	*Acacia permixta*, var. *glabra.*
Wynruit	*Acacia detinens.*
Wilde Sering	*Burkea africana.*
Witgat	*Boscia rehmanniana.*
Wonderboom	*Boscia rehmanniana.*

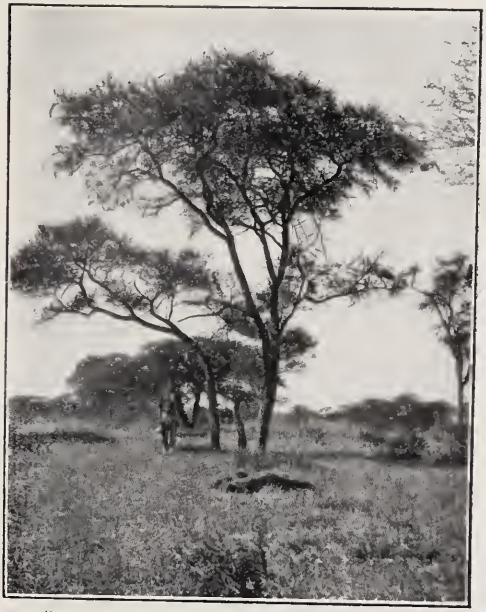

Fig. 1.] [*Photo by E. E. Galpin.*

Acacia Benthami, Rochbr.
(Lekkerruikpeul)
The bent tree in the background is *Acacia litakunensis.*

Fig. 2.] [*Photo by E. E. Galpin.*

Acacia Burkei Benth. (Knopiesdoring).
On farm Gruisfontein No. 7001

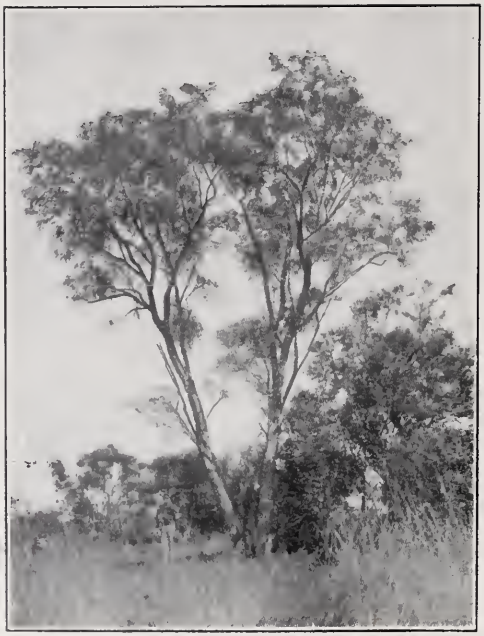

Fig. 3.]

Acacia caffra, Willd.

(Kaffir Wag'nbietjie.)

Fig. 4.]

Photo by E. A. Galpin.

Acacia detinens Burch. (Wynruit).

On Groot Valley.

Fig. 5.] [*Photo by E. E. Galpin.*

Acacia retinens, Sim. (Swarthaak).
On Rood poort.

Fig. 6.] [*Photo by E. E. Galpin.*

Acacia Gerrardi Benth. (Aapkop).
On Roodepoort. Also *A. Gerrardi* in background on the left.

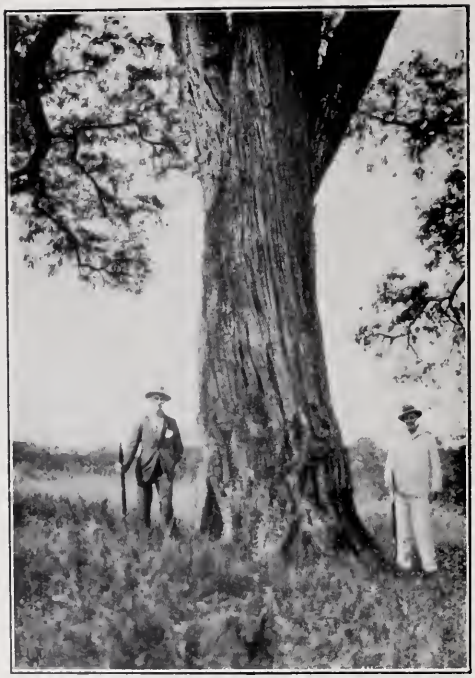

Fig. 7.] [*Photo by E. A. Galpin.*

Acacia Galpinii Burtt Davy (Aapiesdoring).

On farm Nooitgedacht No. 21 3.

Fig. —] [*Photo by E. A. Galpin.*

Acacia Galpinii Burtt Davy (Aapiesdoring).

On farm Nooitgedacht No. 2139.

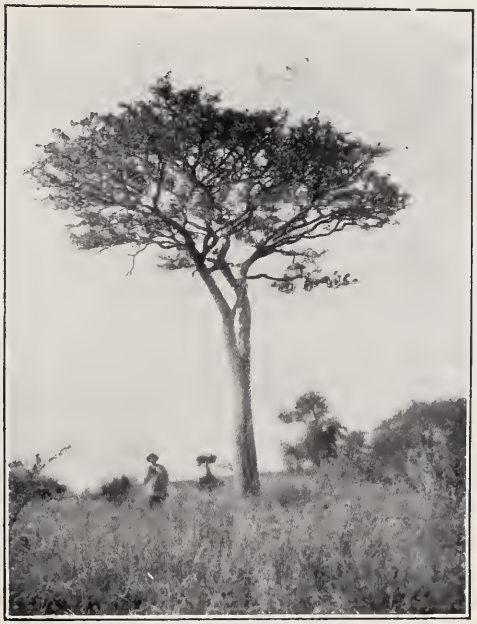

Fig. 9.]

Acacia giraffae, Burch.
(Kameeldoring.)

Fig. 10.]

[*Photo by I. B. Pole Evans.*

Acacia hebeclada DC.
Wonderboom Poort, Pretoria. June, 1917.

Fig. 11.] [*Photo by E. E. Galpin.*

Acacia Karoo Hayne (Sweet thorn).
On farm Roodepoort No. 1974.

Fig. 12.] [*Photo by E. E. Galpin.* 29/6/24.

Acacia lasiopetala Oliver (Mokhaba).
On farm Ongegund No. 2280.

Fig. 13.] [*Photo by E. E. Galpin.*

Acacia litakunensis Burch. (Haakensteek).
On farm Roodepoort No. 1974.

Fig. 14.] [*Photo by E. E. Galpin.*

Acacia Robusta Burch. (Ouboring).
On Roodepoort.

Fig. 15.] [*Photo by E. E Galpin.* 29/6/24.

Bolusanthus speciosus Harms (Olifantsbos).
On farm Ongegund No. 2280. (All specimens there have been pollarded by natives.)

Fig 16.] [*Photo by E. A. Galpin.*

Boscia rehmanniana Pest. (Witgat).
Dichrostachys nutans Benth. in right foreground. On Du Toit's Kraal.

Fig. 17.] [*Photo by I. B. Pole Evans.*

Boscia albitrunca Gilg and Benedict. (Witgat).
On farm Goedgelegen No. 347.

Fig. 18.] [*Photo by E. E. Galpin.* 12/6/24.

Burkea africana Hook. (Wilde Sering).
On farm Zijferkraal No. 1968.

Fig. 19.] [*Photo by E. E. Galpin.*

Combretum apiculatum Sond. (Rooibos).
On farm Roodepoort No. 1974.

Fig. 20.] [*Photo by E. E. Galpin.*

Combretum Guenzii Sond. (Mogoelet-bane).
Vitex sp.) Galpin M.282, on the left. On farm Gruisfontein No. 2001.

Fig 21.] [*Photo by H. M. Galpin.*

Combretum imberbe Wawra, var. *Petersii*, Engl. and Diels. (Hardekool).
On Rietfontein No. 1440.

Fig 22.] [*Photo by H. L. Galpin.*

Combretum Rhodesiacum, Bkr. f. (Kierie Klapper).
On farm Roodepoort No. 1974.

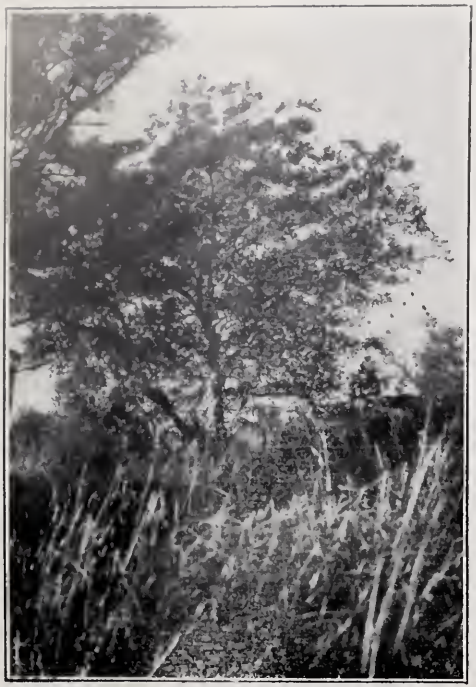

Fig. 24.] [*Photo by E. E. Galpin.* 29/6/24.

Combretum erythrophyllum Sond. (Vaderlands Wilge).
On farm Ongegund No. 2280.

Fig. 25.] [*Photo by L. E. Galpin.*

Combretum Zeyheri Sond. (Raasbos).
On farm Voordeel No. 1958.

Fig. 25.] [*Photo by E. E. Galpin.*]

Cussonia natalensis Sond. (Nooisboom).
On farm Mooihoekspoort No. 1978.

Fig. 26.] [*Photo by E. E. Galpin.*

Dichrostachys nutans Benth. (Sekelbos).
On farm Roodepoort No. 1974.

Fig. 27. [*Photo by L. E. Galpin.*

Dombeya rotundifolia Harvey (Drolpeer).
On farm Roodepoort No. 1974.

Fig. 28.] [*Photo by E. E. Galpin.*

Faurea saligna Harvey (Beukehout).

On farm Roodepoort.

Fig. 29.] [*Photo by E. E. Galpin.* 29/6/24.

Ficus sp. (Wild Fig).

Encircling a morula tree, which is very much suppressed and not visible. On farm Ongegund No. 2280.

Fig. 30.] *Photo by E. E. Galpin.* 29/6/24.

Ficus capensis Thb. (Wild Fig).

Ancient specimen on farm Ongegund No. 2280.

Fig. 31.] [*Photo by E. E. Galpin.*

Gymnosporia buxifolia Linn. (Pendoring).

On farm Roodepoort No. 1974.

Fig. 32 [*Photo by E. A. Galpin.*

Lann a discolor Engl. (Dikbas).

On farm Nooitgedacht No. 2139.

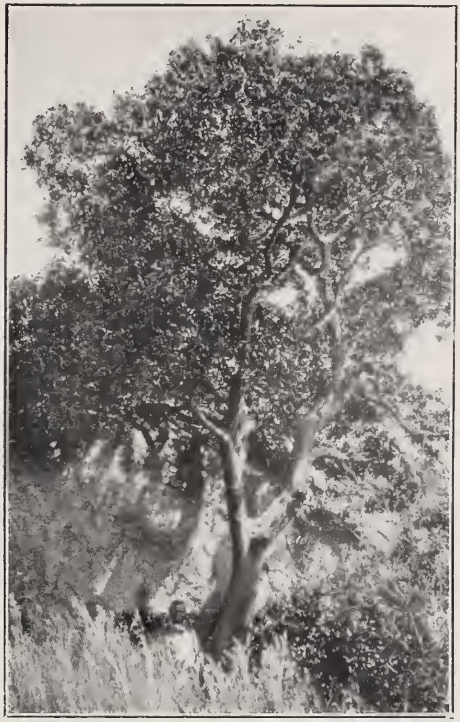

Fig. 33.] [*Photo by H. M. Galpin.*

Mimusops Zeyheri Sond. (Moepel).
On Rietfontein No. 1440.

Fig. 34.] [*Photo by H. M. Galpin.*

Ochna pulchra Hook. (Seerbos).
On farm Roodepoort No. 1974.

Fig. 35. [*Photo by H. M. Galpin.*

Olea verrucosa Link. (Wild Olive).
On farm Rietfontein No. 1440.

Fig. 36. [*Photo by E. E. Galpin.* 11/6/24.

Pappea fulva Conrath, central tree (Noupitjie).
On farm Klipput No. 1925.

Fig. 37.] [*Photo by E. E. Galpin.*

Peltophorum africanum Sond. (Kajatchout).
On farm Zijferkraal.

Fig. 38.] [*Photo by H. M. Galpin.*

Rhamnus Zeyheri Sond. (Red Ivory).
On farm Rietfontein No. 1140.

Fig. 43.] [*Photo by E. E. Galpin.* 11/6/24.

Sclerocarya caffra, Sond (Morula).
On farm Klipput No. 1925.

Fig. 44.] [*Photo by E. E. Galpin.* 11/6/24

Scolopia Mundii Szyszy. var. *Engleri* Phillips. (Galpin M 690) (Thorn Pear). The tall tree with two very long bare stems.

Immediatly behind with short stem, branching into three, is *Combretum apiculatum* Sond. On farm Klipput No. 1925.

Fig. 45.] [*Photo by E. E. Galpin.*

Securidaca longipedunculata Fres. (Krinkhout).
Another specimen in right background. On farm Voordeel No. 1958.

Fig. 46.] *Photo by E. E. Galpin.*

Spirostachys africanus Sond. (Thombotti).
Background left to right: *Zizyphus mucronata* Willd., *Boscia Rehmanniana* Pest., *Combretum Rhodesiacum*. On Du Toit's Kraal.

Fig. 47. [*Photo by E. E. Galpin.*

Strychnos pungens Soler. (Botter Klapper.)
On farm Voordeel No. 1958.

Fig. 48. [*Photo by E. E. Galpin.*

Strychnos Schumanniana Gilg. (Suur Klapper).
On farm Voordeel No. 1958.

Fig. 49.] [*Photo by E. A. Galpin.*

Terminalia sericea Burch. (Vaalbos).
To the left in far background, *Peltophorum africanum* Sond. On Du Toit's Kraal.

Fig. 50.] [*Photo by E. E. Galpin.*

Vitex sp. (Pypsteel).
On Du Toit's Kraal.

Fig. 51. [*Photo by E. L. Galpin.*

Zizyphus mucronata Willd. (Blinkblaar Wag'nbietjie).
On farm Roodepoort.

BOTANICAL SURVEY OF SOUTH AFRICA

MEMOIR No. 8

Researches on the Vegetation of Natal

SERIES II

INCLUDING ACCOUNTS OF INVESTIGATIONS ON

(1) The Water Relations of some Natal Plants, with special reference to the leaves of ***Ptaeroxylon utile*** and ***Portulacaria afra.***

(2) The Water-retaining Capacity of certain Woods in relation to their Microscopic Structure.

(3) The Water Requirement and Transpiration of a common Natal Weed, ***Bidens pilosa*** (L.)

By J. W. BEWS, M.A., D.Sc., and R. D. AITKEN, D.Sc.

To be had from the Librarian, Agricultural Department, Union Buildings

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To the Director,

Union Botanical Survey.

Dear Dr. Pole Evans,

I have much pleasure in submitting to you a second series of researches on the vegetation of Natal. As in the case of the first series (Memoir No. 5 of the Survey), the work has been carried out with the assistance of various M.Sc. students.

Mr. A. P. D. McClean has made a promising beginning in the investigation of the common blackjack (*Bidens pilosa*) as an indicator plant or phytometer for use in South Africa; Miss P. Bangley has worked on the water-retaining capacity of various timbers during the process of seasoning; Mr. R. A. Dyer has investigated various details in connexion with the water-relations of different plants; and other students have been engaged in similar researches which are not yet completed.

For his work on the water-relations of various Natal plants and other published papers, Mr. R. D. Aitken has been awarded the degree of Doctor of Science by the University of South Africa.

I am,

Yours faithfully,

J. W. BEWS.

Natal University College,
Pietermaritzburg, 22nd May, 1925.

Division of Botany,
Pretoria, 8th June, 1925.

The Secretary for Agriculture,

Sir,—I have the honour to transmit herewith the manuscript of a second series of papers prepared by Professor J. W. Bews, the botanist in charge of the eastern area for the Botanical Survey of South Africa.

The whole work has a very distinct economic bearing, since our chief agricultural problems in this country are more or less bound up with the influence of aridity and the water requirements of our crops.

This work is really a continuation of that published in our Botanical Survey Memoir No. 5 of 1923, and I therefore beg to recommend that the present MSS. be now published as Series II of "Researches on the Vegetation of Natal" as a further memoir.

I have the honour to be,

Sir,

Your obedient Servant

I. B. POLE EVANS,

Director, Botanical Survey of South Africa.

Researches on the Vegetation of Natal.

SERIES II.

SECTION I.

The Water Relations of Some Natal Plants, with Special Reference to the Leaves of "Ptaeroxylon utile" and "Portulacaria afra."

Introduction.

During the last ten or twelve years very considerable progress has been made in the study of the plant ecology of Natal, and a fairly thorough survey of the three main botanical regions—Coast-belt, Midland, and Drakensberg—has been completed. In the course of this work all the main types of plant community and the characteristics of the usual habitat of each have been described, and the composition of the more important communities analysed. As a result, there emerges quite clearly the fact that, in a general way, the differences between the various habitats are mainly climatic and that edaphic factors are of only minor importance. Up to the present time, however, comparatively little has been done in the way of detailed physiological and anatomical study of the principal ecological types, though the information to be obtained in this way may be expected to throw very considerable light upon the causes underlying the differences in the physiognomy and composition of the principal plant communities. The first step in this direction was an investigation, carried out in the laboratory of the Natal University College, by a post-graduate student of the comparative size of the aeration system of a number of Natal plants (4).

In the course of the last few years further data have gradually been collected which yield much information as to the water relations of some of our more important trees and shrubs. This information seems at least to point the way to clearer ideas on the subject of the relative xerophytism of these species and the causes underlying their distribution in the different types of habitat. Before proceeding, therefore, to the presentation and discussion of the experimental results, a brief description will be given of the principal communities from which the plants studied have been taken.

The Plant Communities of the Midlands of Natal.

The midlands of Natal, to which region attention has been entirely devoted in the present investigation, are divided into two very distinct climatic areas. On the higher levels, on the ridges between the deep river-valleys, where the maximum deposition of moisture occurs, is the high veld, and in the dry, hot valleys between the ridges is the low veld. The principal physical differences between the two areas have been dealt with in some detail by one of us in "The Vegetation of Natal" (3), and are there summarized as follows:—"The high veld region receives much more deposition of moisture in the form of both rain and mist; its southern and south-eastern slopes are sheltered from the dry, hot winds which always blow from the north or north-west; it does not have such extremes of temperature, being cooler during the day and warmer during the night, cooler in summer and warmer in winter; it suffers comparatively little from frosts, especially inside the bush. The low veld region is very dry, for the rain-bearing clouds tend to pass over it without much deposition of moisture, until they strike the hills. During the winter—when there is usually a still atmosphere—the cold air sinks into the valleys, and the temperature is therefore lower than on the hills; a cold frosty mist forms at night over the low veld."

These climatic differences quite clearly have a considerable effect upon the vegetation. In the grassveld the dominant grasses in the two regions belong to the same species, but differ markedly in their habit. *Themeda triandra* is nearly always the dominant grass in each case. In the high veld it always flowers, and the flowering culms are two or three feet high. In the low veld it is loosely tufted and flowers less frequently. Associated with *Themeda* are various species of *Andropogon*, *Digitaria*, *Aristida*, *Eragrostis*, *Sporobolus*, *Panicum*, and others. Generally speaking, the grasses found in the high veld all grow tall and flower regularly, whereas those of the low veld only flower sporadically, and consequently do not grow so tall and rank.

The differences between high and low veld are, however, much more striking in the case of tree-growth forms than in the case of the grasses. Two main types of tree-growth may be distinguished—close bush and tree veld. These exhibit very pronounced differences, both in their general physiognomy, and also in the plant succession which leads to their formation. Close bush, as the name implies, forms a dense and luxuriant growth of tall trees and shrubs, which often cover a considerable area of ground. Tree veld, on the other hand, consists of isolated trees, scattered through the grass veld and giving a somewhat park-like appearance to the landscape. In the shade of these scattered trees other trees and shrubs may appear, and in this way small irregular clumps may be formed. This type of succession occurs in both high and low veld, though it is of very different composition in each, but close bush is confined entirely to the high veld, and even there it occurs only in those regions where the maximum deposition of moisture takes place, that is, on the south-eastern slopes.

These slopes face the rain-bearing clouds and are, at the same time, protected from the dessicating effects of the hot, dry winds which blow from the north-east at the end of the winter season. In consequence, the soil here contains a higher percentage of moisture,

while the atmospheric conditions are less favourable to evaporation than on the opposite slopes. Some idea of the differences between the two slopes may be gained from an investigation, the results of which have already been published (2). Two stations, within fifteen minutes' walk of each other, were selected, one on each side of a hill near Pietermaritzburg, and records were kept of various environmental factors throughout a whole day. The most important differences observed were that the evaporation from porous cup atmometers was nearly twice as great on the northern slope as on the southern; the northern slope also received about 50 per cent. more insolation than the southern, and its soil temperature was considerably higher than that of the southern. A sample of soil from the former slope was found to have a moisture-content of 12 per cent., and one from the other slope a moisture-content of 25 per cent. Low veld is very much drier than even the north-facing slopes of the high veld and supports a distinctly xerophytic type of vegetation. Thorn trees are particularly common and act as pioneers in the invasion of the grassland. In the shade cast by these, other trees and shrubs make their appearance, and in this way somewhat dense clumps may be formed.

The pronounced differences between the climatic factors of these two main regions is accompanied by a very marked contrast in the composition of the principal plant communities occurring in them. For example, close bush is strikingly different from thorn veld, not only in appearance but also in composition. In the former the dominant trees are usually *Podocarpus latifolia* and *P. falcata*. In moister situations *Xymalos monospora* is often dominant. Associated with these are *Combretum kraussii*, *Olea laurifolia*, *Olea foveolata*, *Celtis rhamnifolia*, *Kiggelaria dregeana*, *Calodendron capense*, *Fagara davyi*, *Ficus natalensis*, and many others. In thorn veld the principal trees are various species of *Acacia* (*A. karroo* and *A. benthami* are the chief pioneers), and associated with these are *Gymnosporia buxifolia*, *Ehretia hottentotica*, *Zizyphus mucronata*, *Hippobromus alata*, *Sclerocarya caffra*, *Plectronia* spp., and others. For the most part, therefore, the species composing the two formations are very distinct, but there are a few cases of species which are common to both. *Ptaeroxylon utile*, for example, is common in close bush, but also occurs in a somewhat stunted form in thorn veld. *Cussonia spicata* is nearly always present in close bush, particularly in its early stages, and is also fairly common in thorn veld.

On the north-eastern slopes of high veld, which are intermediate in their physical characteristics between thorn veld and close bush, there is a distinct intermingling of bush and thorn veld species. Acacias themselves are usually absent, but *Cussonia spicata*, *Combretum kraussii*, *Zizyphus mucronata*, *Heteromorpha arborescens*, *Greyia sutherlandi*, and *Panax gerrardi* are common. More distinctly forest species, such as *Ficus capensis* and *Maesa rufescens* are occasionally found, but usually only in the neighbourhood of water.

Since the main physical differences between the various habitats are such as are likely to have their principal effect upon the processes of water loss and water absorption, it seems very probable that the differences in the covering vegetation are, to some extent at least, due to differences in the ability of the various plants to regulate these processes. The ability of the leaves in particular to retard transpiration and maintain a high water-content may be of special significance

in determining the distribution of plants amongst the different habitats. Generally, one might expect to find that the leaves of trees growing in the thorn veld were better adapted to prevent water loss than those confined to the close bush.

In addition to the differences between the habitats, the seasonal changes must also be considered as having a very considerable effect upon the water relations of our Natal plants. Summer and winter are most clearly distinguished by the difference in rainfall. During the six months from October to March there is an average monthly rainfall of 5 to 6 inches, while from April to September the average is just over 1 inch. June and July are particularly dry months, with an average of only 0.35 inch. Following upon the rainy season, therefore, all our plants are subjected to a long dry period, during which the water-content of the soil is lowered, while the atmospheric conditions still remain favourable to high rates of evaporation. The effects of this dry season will, of course, be more or less pronounced according to the nature of the habitat. Thus close bush, from its very nature, protects the underlying soil from any great loss of moisture by evaporation and is sheltered by its situation on the south-eastern slopes from the effects of the hot, dry winds, which are most common at the end of the winter season. In the low veld, on the other hand, the soil becomes hard and baked and dry during the winter months, and the trees are exposed to the full effects of the hot winds.

All these considerations indicate the importance of a careful study of the water relations of the plants. In the present investigation the aim has been first of all to compare plants, representative of distinct ecological habitats, with regard to their ability to retain water under unfavourable conditions, and, secondly, to determine the extent to which plants of the low veld are able to maintain their water-content during the dry season.

I.—The Water-retaining Power of the Leaves.

A.—Method and Expression of Results.

The classification of plants as xerophytes or mesophytes is, as a rule, based upon their morphological and anatomical features, such as reduction of leaf surface, formation of protective coverings, production of thick cuticle, and sinking of the stomata below the surface of the leaf, and so on. Comparatively few attempts seem to have been made to place the classification upon an experimental basis by studying the effect of these modifications upon the actual process of water loss. In consequence, plants are usually described simply as xerophytes or mesophytes without any indication as to their relative xerophytism or mesophytism in comparison with one another. Yet, in the case of leaves, at any rate, it would seem a fairly simple matter to gain some idea of the effectiveness of their structural modifications in retarding evaporation by a comparative study of the rate of water loss from them. Livingston (9) has indeed suggested that " as far as the aerial water relation is concerned, the foliar transpiring power should be a more or less definite quantitative index of the position of any plant, amongst others, in a scale of power to withhold water against its loss by transpiration," and, acting upon this suggestion, Bakke (11) has endeavoured to obtain comparative data by the method of standardized hygrometric paper, by means of which a scale of relative xerophytism or mesophytism might be elaborated.

It may be pointed out here that the majority of the methods commonly used for the study of transpiration do not measure the actual transpiration rate under the environmental conditions. The cobalt-paper method already mentioned, for example, measures the transpiration at the particular temperature as a function of internal conditions only, the effect of external factors such as air movements being eliminated. Methods involving the use of calcium chloride may be said to measure the resisting or retaining power of the leaf at any particular temperature. The leaves, enclosed in a chamber containing calcium chloride, are exposed to an unusually dry atmosphere which tends greatly to increase the rate of evaporation. The results obtained by such methods are therefore probably an indication of the maximum transpiration rates for the particular internal conditions existing at the time in the leaf and for the given temperature. The increase in weight of the calcium chloride may also be regarded as a measure of the ability of the leaf to retard the loss of water under conditions favourable to a high rate of evaporation.

For the purpose of the present investigation it was not necessary to determine the actual rate of transpiration of the leaves studied, since what was really wanted was information as to their ability to retain water when conditions were such as to be likely to cause a reduction of their water-content. For this purpose either of the above methods might have been used, but there seemed a simpler and quicker method than either of obtaining the data required. The principle of this was to measure the rate of loss of water from a leaf which was prevented from making good that loss by further absorption. This could most easily be effected by simply detaching the leaf from the plant and weighing at frequent intervals. A method, similar in principle though more elaborate in detail, has recently been employed by Knight (8) in his work on the inter-relationships of transpiration stomata, leaf water-content, and wilting of plants.

Cut twigs were used and placed in potometers and the water-content of the plant experimentally diminished by closing a stopcock at the base of the potometer. Observations on the rate of transpiration by means of weighings at short intervals were then continued for a period of one or two hours or longer if necessary. In work such as this, aiming at a deeper analysis of the actual process of transpiration, a considerable refinement of method was called for, but in the present investigation, where all that was required was a comparison of a number of plants, such refinement does not appear necessary. Removal of the leaf from the plant is the easiest and quickest way of preventing any further absorption of water, and hence of ensuring the reduction of the water-content. The rate at which the leaves dry will then be a measure of their ability to retain water or to retard transpiration when the water-content is diminishing.

In order to ensure that the results should all be strictly comparable for the different plants, it is necessary that the leaves should always be in the same condition as regards water-content at the beginning of the experiment. This is clearly the more essential in comparing leaves brought from plants at a distance with those from plants growing in close proximity to the laboratory. The only way of effecting this is to restore all the leaves to their maximum water-content before beginning the experiment. In every case, therefore, twigs of the plants to be studied were brought into the laboratory and

placed with their cut ends in water, under a bell-jar, for some hours until a deposition of water on the sides of the bell-jar became evident. The question of whether the condition of turgidity thus ensured is ever really attained under natural environmental conditions is one which will be discussed later, when evidence will be submitted to show that at certain seasons such a condition is, at all events, very nearly attained. When the leaves had been prepared in this way they were detached from the twig and weighed and then placed in an incubator, kept at a constant temperature of 25° C. The rate of drying was then followed at regular intervals for a period of two or three hours. After this the leaves were transferred to a steam oven and thoroughly dried at a temperature of 100° C. and their dry weight was thus determined

Some attention was given to the question of the best method of expressing the results obtained. Transpiration rates are usually expressed in terms of either unit area of leaf surface or percentage of fresh weight. In the present instance the former is clearly an unsuitable standard, and it was at first decided to use the latter. The fresh weight of the leaf is, however, made up of two components—dry weight plus water-content. In the experiments to be described only the latter of these components was varying, and the aim of the experiment was to determine the extent by which this component was lowered in a given time. The best method, therefore, of expressing the results seemed to be in terms of the original water-content, and in order to do this the amount of water lost in each interval is calculated as a percentage of the total amount of water present in the leaf when fully turgid, a method used in previous investigations (4).

It may be mentioned here that an account of an exactly similar method of measuring the relative water-retaining capacity of the tissues of plants, subjected to different treatments and of known degrees of hardiness, has recently been given by Boswell in the *Botanical Gazette* (5). Cabbage and tomato plants were used, and the leaves were dried at a temperature of 60° C. They were weighed immediately upon removal from the plant, and then at fifteen-minute intervals. The results showed that in every case the hardy tissue (plants grown in a cold frame) lost water less rapidly than the tender tissue (plants grown in a greenhouse).

B.—Experimental Results.

(1) In the first experiment the plants used were all growing in the Natal University College grounds, and were representative of three very distinct ecological types. *Podocarpus henkelii* is a dominant forest species; *Ptaeroxylon utile* has already been mentioned as a forest species, though it frequently occurs also in the thorn veld. *Portulacaria afra* is a large shrub with small fleshy leaves; it is a common pioneer in low veld, occurring particularly in dry river-valley scrub. Since the grounds of the college are situated in a distinctly low veld area the *Podocarp* was growing in a very unnatural habitat, but appeared to be fairly healthy at the time of the experiment. As a result of a prolonged drought in the following summer it clearly suffered very considerably in comparison with other true low veld trees growing in the neighbourhood. The rate of water loss from the three kinds of leaves is shown in Table I.

TABLE I.

Rate of Water Loss from Leaves of Podocarpus henkelii, Ptaeroxylon utile, *and* Portulacaria afra. *3rd March*, 1922.

Time in Hours.	*Podocarpus henkelii.*		*Ptaeroxylon utile.*		*Portulacaria afra.*	
	Water-content per cent. of Original Water-content.	Loss per Hour per cent. of Original Water-content.	Water-content per cent. of Original Water-content.	Loss per Hour per cent. of Original Water-content.	Water-content per cent. of Original Water-content.	Loss per Hour per cent. of Original Water-content.
0	100	—	100	—	100	—
1	93·24	6·36	73·55	26·45	98·17	1·83
2	87·54	5·70	63·63	9·92	96·87	1·30
3	81·81	5·73	57·85	5·78	95·68	1·19
Water-content in per cent. of turgid weight.	58·40		61·88		92·21	

Of the three types, the fleshy leaves of *Portulacaria afra* are clearly the most retentive of water, and even after three hours' drying the amount of water lost only amounts to 4.32 per cent. of the total amount of water originally present in the leaves. In comparison with this the leaves of both *Podocarpus henkelii* and *Ptaeroxylon utile* lost considerably greater proportions of their original water-content during one hour's drying than did the leaves of *Portulacaria afra* in the whole three-hour period. Of the three, the leaves of *Ptaeroxylon utile* lost by far the most rapidly, over 26 per cent. of the water originally present in them being evaporated in one hour. The very marked difference between *Ptaeroxylon utile* and *Podocarpus henkelii* in this respect is somewhat surprising in view of the difference in their distribution. This result clearly shows that leaf characters are not in themselves a sufficient basis for deciding the relative xerophytism or mesophytism of the entire plant. In this case there can be no doubt that on the basis of habitat *Podocarpus henkelii* must be regarded as more mesophytic than *Ptaeroxylon utile*, yet its leaves are clearly better fitted to prevent a rapid lowering of the water-content than are those of *Ptaeroxylon*. Bakke (11) has already pointed out in connection with his suggested use of the cobalt chloride paper method as a means of elaborating a scale of relative xerophytism or mesophytism that "a classification based upon leaf transpiring power is quite without reference to the relative water-absorbing powers of roots or the relative conducting power of stems," but he considers that "such a classification should be vastly more satisfactory in use than the vague ecological classification usually employed, based as it is on the appearance of the plant and the judgment of the observer." The present instance, and another to be mentioned later, suggest, however, that such a classification may at times be very misleading. The xerophytic character of the leaves may be quite as much a response to internal factors in the structure of the plant as to the external factors of the environment, and may be an altogether insufficient criterion of the true water requirements of any plant. In this case, for example, Podocarpus, being a conifer, probably has

wood of relatively low water-conducting power, and this may be the factor which has resulted in the development of a xerophytic type of leaf structure. Further reference will be made to this later.

Another point which attracts attention in the above table is that in the case of *Ptaeroxylon utile* there is a very marked change in the rate of loss after the first hour. It seems possible to account for this in one of two ways, and the data are at present insufficient to decide definitely between these. It may be that at the beginning of the experiment the stomata are widely open, and in response to the falling water-content they slowly close, and as this closure becomes more pronounced a definite check is placed upon the rate of loss. If it really is the case that this is the sole factor concerned, the results indicate that closure of the stomata effects a very considerable reduction in the rate of water loss, but it would seem that the closure takes place very slowly in response to a diminishing water-content in view of the fact that 26 per cent. of the total water originally present is lost in the first hour. On the other hand, it is possible that the lowered water-content is in itself responsible for the check upon the rate of loss. Probably, if any saturated tissue is allowed to dry, the initial loss of water will be fairly rapid; later, cohesion and adhesion forces will come into play and cause a considerable diminution in the rate of loss. In this connexion it may be mentioned that some experiments on the drying-out of wood, recently conducted in this laboratory (see Section II of this Memoir), showed a very similar phenomenon of a pronounced falling off in the rate of loss after the first few hours. In the case of the leaves it might be possible to decide which of these two explanations is the more probable by means of porometer experiments, and attempts to do this will be mentioned later. There seems some reason to suppose, however, that both stomatal closure and decrease of the water-content have a part in checking the rate of loss.

(ii) In the second experiment four plants were investigated—*Podocarpus falcata*, *Protea roupelliae*, *Greyia sutherlandi*, and *Crassula* sp. All the twigs used were from plants growing on the Zwaartkop mountain, near Maritzburg. *Podocarpus falcata* is a forest species; *Protea roupelliae* and *Greyia sutherlandi* are typical tree veld species of the high veld, both found growing in close proximity on the rocky, north-facing slopes of the mountain. *Crassula* sp. is a small, succulent plant growing on top of the mountain. The results are shown in Table II. Here, again, it will be noticed that the succulent leaves lose water least rapidly of all, and even after five and a half hours' drying still retain 86 per cent. of their original water-content. The leaves of *Protea roupelliae* and *Podocarpus falcata* both lose water comparatively slowly and at about the same rate. Those of *Greyia sutherlandi* are considerably less resistant to water loss than any of the others. In each case it will be noticed that there is a falling off in the rate of loss after the first hour, but that this is specially marked in the case of *Greyia sutherlandi*. It is not, however, until the end of the second hour that the rate of loss from these leaves becomes comparable with that from the leaves of *Podocarpus* and *Protea*.

TABLE II.

Rate of Water Loss from Leaves of Podocarpus falcata, Protea roupelliae, Greyia sutherlandi, Crassula *sp.*

Time in Hours.	*Podocarpus falcata.*		*Protea roupelliae.*		*Greyia sutherlandi.*		*Crassula* sp.	
	Water-content per cent. of Original Water-content.	Loss per Hour per cent. of Original Water-content.	Water-content per cent. of Original Water-content.	Loss per Hour per cent. of Original Water-content.	Water-content per cent. of Original Water-content.	Loss per Hour per cent. of Original Water-content.	Water-content per cent. of Original Water-content.	Loss per Hour per cent. of Original Water-content.
0.....	100	—	—	—	—	—	100	—
1.....	94·82	5·18	100	—	100	—	96·32	3·68
2.....	90·22	4·60	95·35	4·65	87·10	12·9	93·24	3·08
3.....	85·18	4·04	91·37	3·98	79·56	7·54	90·97	2·27
5¼.....	77·62	3·02	83·07	3·32	67·16	4·96	86·40	1·83
Water-content per cent. of turgid weight	52·11		66·80		67·53		84·53	

These two experiments, having shown that the rate of loss of water during drying may be very rapid and result in more than 10 per cent. of the water originally present being lost in the course of one hour, it was thought advisable in the future to weigh the leaves at shorter intervals. This seemed necessary in order to gain a clearer idea of the rate of water loss during the period before the marked falling off in the rate which frequently occurs in the second hour. In all the succeeding experiments, therefore, the leaves were weighed at intervals of twenty or thirty minutes, and the weighings continued over a period of two or three hours.

(iii) Several experiments were next conducted to compare different leaves from the same tree and in this way determine to what extent a few leaves picked at random from the tree may be regarded as representative of the leaves as a whole. In the first of these experiments two lots of four leaflets of *Ptaeroxylon utile* and two lots of three leaves of *Cordia caffra* were used. Table III shows the results.

TABLE III.

Rate of Water Loss during Drying of Leaves of Ptaeroxylon utile *and* Cordia caffra. *29th March*, 1923.

Time in Minutes.	*Ptaeroxylon utile* (1).		*Ptaeroxylon utile* (2).		*Cordia caffra* (1).		*Cordia caffra* (2).	
	Water-content per cent. of Original Water.	Loss per 20 mins. per cent. of Original Water.	Water-content per cent. of Original Water.	Loss per 20 mins. per cent. of Original Water.	Water-content per cent. of Original Water.	Loss per 20 mins. per cent. of Original Water.	Water content per cent. of Original Water.	Loss per 20 mins. per cent of Original Water
0....	100	—	100	—	100	—	100	
20....	95·27	4·73	97·89	2·11	83·00	17·00	81·79	18·21
40....	93·45	1·82	96·99	0·90	71·99	11·01	71·39	10·40
60....	92·15	1·30	96·04	0·95	63·75	8·24	64·52	6·77
80....	90·80	1·35	95·02	1·02	57·47	6·28	58·06	6·46
100....	89·53	1·27	93·91	1·11	52·62	4·85	52·43	5·63
120....	88·50	1·03	93·05	0·86	48·66	3·96	48·98	3·45
140....	87·39	1·11	92·68	0·97	45·01	3·65	46·17	2·81
160....	86·46	0·93	91·38	0·70	42·00	3·01	43·38	2·79
180....	85·63	0·83	90·32	1·06	38·32	3·68	40·49	2·89
Water-content per cent. of turgid weight	62·27		63·32		70·23		66·24	

The most remarkable feature of these results is the very low rate of loss from the leaves of *Ptaeroxylon utile*. It will be remembered that in the first experiment the leaves of this tree lost over 26 per cent. of their water-content in the course of a single hour; in the present instance they lose only 7.85 per cent. in one case and 3.96 per cent. in the other. It will also be noticed that the two lots of leaves do not agree very closely with one another in their rate of drying out. Some attention was given to the cause of these discrepancies, and experiments in this connexion will be described later.

The leaves of *Cordia caffra* lost water very rapidly in the course of drying, and nearly 40 per cent. of their original water-content was lost in the first hour. In contrast with those of *Ptaeroxylon utile*, the two sets of leaves lost water at a very uniform rate.

(iv) Four sets of leaves of *Heteromorpha arborescens* were next compared, and the results are shown in Table IV.

TABLE IV.

Rate of Water Loss during Drying-out of Leaves of Heteromorpha arborescens. *31st March*, 1923.

Time in Minutes.	1.		2.		3.		4.	
	Water-content per cent. of Original Water-content.	Loss per 20 mins. per cent. of Original Water-content.	Water-content per cent. of Original Water-content.	Loss per 20 mins. per cent. of Original Water-content.	Water-content per cent. of Original Water-content.	Loss per 20 mins. per cent. of Original Water-content.	Water-content per cent. of Original Water-content.	Loss per 20 mins. per cent. of Original Water-content.
0....	100	—	100	—	100	—	100	—
20....	94·76	5·24	91·67	8·33	91·42	8·58	92·67	7·33
40....	91·69	3·07	89·77	1·90	89·73	1·69	90·30	2·37
60....	90·55	1·14	88·68	1·09	88·76	0·97	89·20	1·10
80....	88·38	2·17	87·82	0·86	88·07	0·69	88·50	0·70
100....	87·63	0·75	87·05	0·77	87·38	0·69	87·54	0·96
120....	86·67	0·96	86·34	0·71	86·61	0·67	86·74	0·80
140....	85·76	0·91	85·40	0·94	85·98	0·63	85·98	0·76
160....	84·92	0·84	84·66	0·74	85·34	0·64	85·15	0·83
180....	84·06	0·86	83·72	0·94	84·71	0·63	84·42	0·73
Water-content per cent. of turgid weight	75·15		74·43		74·58		74·13	

These four sets of leaves show a very similar rate of water loss, though No. 1 is rather slower than the others at first. There is a very decided check upon the rate of loss after the first twenty minutes, and, whatever may be the cause of this, it seems to be definitely connected with the extent of reduction of the water-content. No. 1, for example, loses only about 5 per cent. in the first period, whereas the others lose from 7 to 8 per cent. In the next period the loss from No. 1 is 3 per cent., and that from the others about 2 per cent. The rate of loss then becomes approximately the same in all four, and at the end of eighty minutes they have all lost practically the same percentage of their water.

A similar experiment was next carried out with four sets of leaves of *Podocarpus henkelii*, the results of which are given in Table V. Here, again, there is a fairly close agreement between the four different lots of leaves.

These three experiments (Tables III, IV, and V) indicate that, except in the case of *Ptaeroxylon utile*, leaves of the same plant dry out at approximately the same rate, and that therefore in these cases a few leaves may be taken as fairly representative of all. The fact that this does not hold in the case of *Ptaeroxylon utile* shows, however, the need for testing it in every case.

Table V.

Rate of Water Loss during Drying of Leaves of Podocarpus henkelii. *28th April*, 1923.

Time in Minutes.	1.		2.		3.		4.	
	Water-content per cent. of Original Water-content.	Loss per 20 mins. per cent. of Original Water-content.	Water-content per cent. of Original Water-content.	Loss per 20 mins. per cent. of Original Water-content.	Water-content per cent. of Original Water-content.	Loss per 20 mins. per cent. of Original Water-content.	Water-content per cent. of Original Water-content.	Loss per 20 mins. per cent. of Original Water-content.
0.....	100	—	100	—	100	—	100	—
20.....	96·28	3·72	95·88	4·12	96·24	3·76	95·12	4·88
40.....	94·16	2·12	93·49	2·39	94·16	2·08	92·19	2·93
60.....	92·18	1·98	91·36	2·13	92·10	2·06	89·26	2·93

(v) Several experiments were next conducted to obtain data with regard to the leaves of trees which show a distinct preference for a moist habitat. These selected were *Xymalos monospora*, which is confined to the moistest parts of the bush, *Ficus capensis* and *Maesa rufescens*, both of which generally occur in the neighbourhood of water. The results of two typical experiments are recorded in Tables VI and VII.

Table VI.

Rate of Water Loss during Drying of Leaves of Xymalos monospora, Ficus capensis, *and* Ptaeroxylon utile. *24th October*, 1923.

	Xymalos monospora.			*Ficus capensis.*			*Ptaeroxylon utile.*	
Time in Minutes.	Water-content per cent. of Original Water-content.	Loss per 20 mins. per cent. of Original Water-content.	Time in Minutes.	Water-content per cent. of Original Water-content.	Loss per 20 mins. per cent. of Original Water-content.	Time in Minutes.	Water-content per cent. of Original Water-content.	Loss per 20 mins. per cent. of Original Water-content.
0.....	100	—	0.....	100		0	100	—
18.....	99·00	1·11	16.....	94·95	6·31	16....	96·77	4·04
37.....	97·86	1·19	35.....	92·51	2·57	37....	94·43	2·28
55.....	96·56	1·23	55.....	89·76	2·75	55....	92·55	2·10
77.....	95·45	1·17	75.....	87·28	2·48	73....	90·54	2·23
Water-content per cent. of turgid weight	76·47			66.71			18·12	

Table VII.

Time in Minutes.	*Maesa rufescens.* Water-content per cent. of Original Water-content.	*Maesa rufescens.* Loss per 15 mins. per cent. of Original Water-content.	Time in Minutes.	*Ficus capensis.* Water-content per cent. of Original Water-content.	*Ficus capensis.* Loss per 15 mins. per cent. of Original Water-content.
0.....	100	—	0.....	100	—
15.....	95·28	3·54	16.....	94·39	5·26
32.....	89·66	4·95	30.....	89·64	5·09
48.....	85·61	3·79	46.....	85·02	4·33
67.....	81·25	3·45	67.....	79·64	3·84
Water-content per cent. of turgid weight	79·56			68·47	

In all of these experiments the leaves were allowed to dry under exactly similar conditions and at the same temperature. The object of this was to enable results obtained at different times to be fairly compared with one another, and thus an idea of the relative water-retaining power of the leaves of the various species to be gained. For this purpose the amount of water lost during the first hour of drying, expressed as a percentage of the amount of water originally present in the leaf, may be regarded as an index of the ability of the leaf to resist the loss of water under conditions making for the lowering of the water-content. From the results obtained it is therefore possible to arrange the plants in the order of the efficiency of the leaves in this respect, and this is done in Table VIII.

Table VIII.

Species.	Water Lost in One Hour per cent. Original Water-content.
Portulacaria afra.....	1·83
Xymalos monospora.....	3·40 (average)
Crassula sp.....	3·68
Protea roupelliae.....	4·65
Podocarpus falcata.....	5·18
Podocarpus henkelii.....	8·30 (average)
Heteromorpha arborescens.....	10·90 (average)
Greyia sutherlandi.....	12·90
Ficus capensis.....	15·07 (average)
Maesa rufescens.....	15·73
Cordia caffra.....	35·86 (average)
Ptaeroxylon utile.....	26·45; 7·85; 3·96; 8·42

In several cases, as will be seen, an average figure is given representing the mean of two or more experiments; in these cases the deviation from the mean is never more than ± 2 per cent. The four values given for *Ptaeroxylon utile* are so divergent that it seems better to record each of them rather than calculate an average. Other results were obtained by allowing the leaves to dry in the laboratory at the ordinary room temperature, and these indicate that the above

order is substantially correct. It will, however, be necessary to refer to those cases only in which an average result has been obtained.

The table clearly shows in the first place that the ability of the leaf to resist water loss is not in itself a sufficient indication of the relative xerophytism or mesophytism of a plant. The first experiment described suggested this and the later experiments confirm it. For example, *Xymalos monospora* must certainly be regarded as the most tropical and most mesophytic of all our Natal trees. It is strictly confined to the close bush formation, and even there it occupies only the wettest situations. Both species of *Podocarpus* are confined to close bush also, and must, on this ground, be regarded as mesophytic. Yet the leaves of all these, and particularly of *Xymalos monospora*, lose water comparatively slowly while drying. At the other end of the scale *Cordia caffra*, which is very common in the dry thorn veld, has leaves which lose water extraordinarily rapidly in comparison with the others. It would seem, therefore, that the development of xerophytic modifications in the leaves, that is, modifications which render the leaves more resistant to water loss, may be a response to other than environmental conditions.

Consideration must also be given to factors involved in the structure of the plant itself, and the structure of the wood and the efficiency of the roots in absorbing water are probably of special significance. It is a somewhat difficult matter to devise means for testing the absorbing power of the root system of a tree, but it is a comparatively easy matter to measure the conducting power of the wood.

C.—The Water-conducting Power of the Wood.

Farmer (7) has described a method of comparing the relative power of different woods to transmit water by the determination of what he has termed the "specific conductivity," which he defines as "the quantity of water transmitted through 1 sq. cm. of wood, 15 cms. long, in 15 minutes under a pressure of 30 cms. of mercury." The method used for the determination was a slight modification of that used by Farmer, which has been previously described by one of us (1), and need only be summarized here. Portions of the twigs to be used were placed in a closed vessel containing distilled water, and the air was drawn out of this vessel by means of a vacuum pump. When bubbles of air ceased to escape from the cut surfaces of the wood the vessel was disconnected from the pump and air allowed to enter. The increased pressure would then force water into the wood, which in this way becomes injected. This process was repeated a number of times to ensure as complete injection as possible. Pieces 15 cms. in length were then cut from the centre of these twigs and attached to the bottom of a long tube leading from an aspirator. In this way water was forced through the twig under a pressure equivalent to 15.5. cms. of mercury, and the quantity transmitted in 15 minutes was measured by collecting it in a measuring flask. The twig was then bisected and a section cut from the centre, and the area of the wood in this section determined by the help of a projection apparatus. From the data thus obtained the specific conductivity of the wood was calculated, and the results shown in Table IX were obtained.

Table IX.

Specific Conductivity of the Wood of Certain Natal Trees.

Species.	Specific Conductivity.
Podocarpus henkelii	14·5
Xymalos monospora	16·95
Ptaeroxylon utile	21·45
Ficus capensis	81·55; 71·17
Cordia caffra	90·55; 52·38
Maesa rufescens	80·71; 122·7

The six plants examined quite clearly fall into two groups, between which there is a very decided difference. *Podocarpus henkelii*, as might be expected, has wood of the lowest conductivity, and it is interesting to find that the conductivity of the wood of *Xymalos monospora* is also very low. In these cases, therefore, it seems that the xerophytic character of the leaves, as indicated by their ability to resist water loss, is probably due to the nature of the wood. It is somewhat surprising, however, to find that the wood of *Ptaeroxylon utile* transmits water so slowly; some of its leaves, at all events, lose water very rapidly, quite as rapidly, in fact, as those of *Maesa rufescens* and *Ficus capensis*, which both have wood of very high conductivity. This suggests that the leaves of *Ptaeroxylon* may be able to withstand a considerable diminution in the water-content or else that the root system is particularly efficient in absorbing water.

It is worth noticing that not only has *Xymalos monospora* wood of low conducting power, but also that its leaves have a very high water-content, which forms 75 per cent. of the fresh weight when the leaves are fully turgid. Possibly it is the combination of these two factors which is the cause of its being confined to the moistest situations in the forest. It is interesting to compare with this *Cordia caffra*, which is a tree of the thorn veld. The leaves of Cordia have nearly as high a water-content (68 per cent.) as those of *Xymalos monospora*, the former lose water far more rapidly than the latter. Yet *Cordia caffra* is able to grow successfully under far drier conditions than is *Xymalos monospora*. Apparently, the ease with which water can pass through the wood of the former is sufficient to enable the leaves to obtain all the water they require even under dry conditions. The structure of the wood may therefore be a factor of considerable ecological significance.

D.—The Variation in the Rate of Loss from Leaves of Ptaeroxylon utile.

Attention has already been drawn to the fact that the figures obtained for the rate of drying out of leaflets of *Ptaeroxylon utile* vary very considerably. A number of experiments were carried out to determine whether this variation could be correlated with some other factor such as the age of the leaf or the position of the leaf on the tree. It was thought that the height of the leaf from the ground might have some effect upon its rate of water loss. A number of experiments were carried out to test this, but only two, typical of the others, need be quoted here.

TABLE X.

Rate of Water Loss during Drying of Leaves of Ptaeroxylon utile *from Different Points on a Single Tree.*

Time in Minutes.	Top of Tree.		Halfway Up the Tree.		Near the Base.	
	Water-content per cent. of Original Water-content.	Loss per Hour per cent. of Original Water-content.	Water-content per cent. of Original Water-content.	Loss per Hour per cent. of Original Water-content.	Water-content per cent. of Original Water-content.	Loss per Hour per cent. of Original Water-content.
0.....	100	—	100	—	100	—
60.....	83·0	17·0	83·8	16·2	88·9	11·1
120.....	71·0	9·0	81·4	2·4	85·8	3·1
180.....	70·7	3·3	79·4	2·0	84·6	1·2

TABLE XI.

Time in Minutes.	Top of Tree.		Halfway Up the Tree.		Near the Base.	
	Water-content per cent. of Original Water-content.	Loss per ½ Hour per cent. of Original Water-content.	Water-content per cent. of Original Water-content.	Loss per ½ Hour per cent. of Original Water-content.	Water-content per cent. of Original Water-content.	Loss per ½ Hour per cent. of Original Water-content.
0.....	100	—	100	—	100	—
30.....	89·5	10·5	96·0	4·0	89·5	10·5
60.....	81·3	8·2	91·6	4·4	78·0	11·5
90.....	74·5	6·8	87·3	4·3	71·0	7·0
120.....	71·3	3·2	83·4	3·9	70·5	0·5

The first of these tables might suggest that the ability to withstand water loss decreases with increased height from the ground, but the second shows that this is not the case. In six experiments in this connexion the rate of loss during the first hour of drying varied from 6.3 per cent. to 27.2 per cent., and no clear indication could be obtained to show that this variation was connected with the position of the leaf on the tree.

Age of the leaf, however, was found to have a very definite effect upon the rate of water loss, and the results presented in Table XII are typical of several experiments. From these it will be seen that both young and old leaves lose water more slowly than mature leaves. This is somewhat difficult to account for, but it may be that the stomata of young leaves close more rapidly in response to a falling water-content.

TABLE XII.

Rate of Water Loss during Drying of Leaves of Different Ages of Ptaeroxylon utile.

in Hours.	Young.		Mature.		Mature.		Mature.		Old.	
	Water-content.	Loss per Hour per cent.	Water-content.	Loss per Hour per cent.	Water-content.	Loss per Hour per cent.	Water-content.	Loss per Hour per cent.	Water-content.	Loss per Hour per cent.
0.....	100	—	100	—	100	—	100	—	100	—
1.....	94·0	6·0	86·5	13·5	85·0	15·0	87·5	12·5	92·0	8·0
2.....	92·0	2·0	83·0	3·5	81·5	3·5	81·8	5·7	87·0	5·0
3.....	89·8	2·2	78·5	4·5	80·0	1·5	79·0	2·8	83·0	4·0
Water-content per cent. turgid weight	70·2		58·4		59·9		57·7		55·0	

It must be pointed out in this connexion that this result does not afford a sufficient explanation of the very low rate of drying out recorded in Table III. In the above experiment the water-content of the young leaves, expressed as a percentage of the fresh weight when the leaf is fully turgid, is about 10 per cent. greater than that of the mature leaves. In all the experiments with mature leaves the water-content has been found to form from 50 to 60 per cent. of the fresh weight, and in the experiment given in Table III it formed in one case 62 per cent. and in the other 63 per cent. These leaves can therefore have been only very slightly, if at all, younger than those generally used.

In all, thirty experiments have been carried out with mature leaves of *Ptaeroxylon utile*. The loss of water during the first hour of drying varies from 4.0 to 27.0 per cent. of the total water originally present in the leaf, the average loss being 15 per cent. Comparing this figure with those given for other leaves in Table VIII, it is seen to be fairly high, and it is somewhat surprising to find such a high rate of drying associated with such a low conductivity of the wood, as has been shown to be the case in *Ptaeroxylon utile*. These facts suggest that the leaves of this tree may undergo considerable variations in water-content in the course of the year, and in the second part of this paper will be found an account of an investigation into this. Before proceeding to that, however, mention will be made of an investigation into the nature of the stomatal movement during the drying of the leaves.

E.—Stomatal Movement during the Drying of the Leaves of Ptaeroxylon utile.

In the preceding pages attention has been repeatedly called to the fact that in the drying out of the leaves of *Ptaeroxylon utile* there is generally a considerable loss of water during the first hour, and that after this the loss per hour becomes very much less. This falling off in the rate of loss may be due to two causes, stomatal closure or the lowering of the water-content itself. In order to obtain further information upon this, the following procedure was adopted:—

A porometer cup was fastened to the under surface of a leaflet which remained attached to the leaf. Some difficulty was found in securing an air-tight connexion between the cup and the leaf as the glue used became very brittle on drying, and did not adhere well to the smooth, glossy surface of the leaf. A satisfactory connexion having been obtained, the leaf was left standing with its cut stalk in water under a small bell-jar for a couple of hours to ensure its complete recovery from the shock caused by handling, while at the same time maintaining its turgidity. The leaflet with the cup attached was then removed from the leaf, and the cup was connected with an aspirator. The pressure used for drawing air through the leaf was equivalent to 12 inches of water. The passage of the air bubbles was extremely slow, and eventually it was found necessary to measure the time elapsing between two successive bubbles only. Readings were taken at intervals of five to ten minutes and are tabulated in Table XIII.

TABLE XIII.

Stomatal Movement during Drying of Leaves of Ptaeroxylon utile. *28th June*, 1923.

Leaf No. 1.		Leaf No. 2.		Leaf No. 3.		Leaf No. 4.	
Time of Reading in Minutes.	Seconds Between Two Successive Bubbles.	Time of Reading in Minutes.	Seconds Between Two Successive Bubbles.	Time of Reading in Minutes.	Seconds Between Two Successive Bubbles.	Time of Reading in Minutes.	Seconds Between Two Successive Bubbles.
0	20	0	52	0	13	0	32
10	19	17	60	10	20	7	34
15	19	27	55	22	24	19	39
20	21	39	49	37	34	31	45
25	24	49	50	47	45	39	50
30	24	61	45	52	53	49	55
40	30	78	47	62	58	64	60
50	31	103	57	92	85	91	80
60	39	116	69	99	90	106	100
70	46	128	70	110	83	116	105
80	52	133	88	117	95	141	115
90	62	158	88	142	96	151	125
100	61	173	95	152	96	181	123
110	65	193	88	162	92	191	135
130	117	203	95	178	92	—	—

From these figures it will be seen that as the drying of the leaf proceeds there is a very decided slowing down in the rate of passage of successive bubbles, which is indicative of a closing of the stomata. This closure, however, appears to take place very slowly, and does not become complete for nearly two hours. Only in the case of leaf No. 3 is there a very large decrease in the rate of bubbling at the end of the first hour. It is very difficult, however, to decide from these figures whether the closure of the stomata alone is sufficient to account for the falling off in the rate of water loss, and an attempt was made to solve this in another way. Two opposite leaflets were picked and one was immediately killed by exposure to steam. The loss of weight from the living and dead leaflets was then followed at half-hour intervals for a period of three to four hours. Table XIV shows the results of two typical experiments.

TABLE XIV.

Loss of Weight during Drying of Living and Dead Leaves of Ptaeroxylon utile.

Time in Minutes.	Leaf No. 1.				Leaf No. 2.			
	Living Leaflet.		Dead Leaflet.		Living Leaflet.		Dead Leaflet.	
	Water-content per cent. Original Water-content.	Loss per Half-hour per cent. Original Water-content.	Water-content per cent. Original Water-content.	Loss per Half-hour per cent. Original Water-content.	Water-content per cent. Original Water-content.	Loss per Half-hour per cent. Original Water-content.	Water-content per cent. Original Water-content.	Loss per Half-hour per cent. Original Water-content.
0....	100	—	100	—	100	—	100	—
30....	92·7	7·3	98·0	2·0	93·2	6·8	97·8	2·2
60....	86·6	6·1	96·3	1·7	86·5	6·7	95·2	2·6
90....	84·2	2·4	91·3	2·0	84·0	2·5	93·0	2·2
120....	82·7	1·5	93·0	1·3	81·0	3·0	91·0	2·0
150....	80·9	1·8	91·2	1·8	78·9	2·1	88·7	2·3
180....	79·5	1·4	89·2	2·0	77·0	1·9	86·3	2·4

It will be seen from the above table that during the first hour there is a very considerable difference between the living and the dead leaflets as regards the loss of water, but that after this drying proceeds in very much the same rate in each. The most probable explanation seems to be that killing the leaf causes the stomata to close, and consequently in the dead leaflets the stomata are closed from the beginning of the experiment. In the living leaflets they remain open, but slowly close during the first hour of drying and become completely closed at the end of the hour. In these two cases, therefore, the check upon the rate of loss after the first hour would seem to be due to the action of the stomata, and it is somewhat remarkable to find that the stomata do not exert a marked check upon the rate of loss until between 13 and 14 per cent. of the water present in the leaves has been lost The conclusion seems to be that the stomata respond very slowly, even to large changes in the water-content.

II.—The Water-content of the Leaves of "Ptaeroxylon utile" and "Portulacaria afra."

The facts so far ascertained with regard to *Ptaeroxylon utile* are in many ways very surprising. It occurs both in the mesophytic bush and also in the dry thorn veld. Its wood does not permit of a rapid passage of water, yet its leaves are far less retentive of water than those of even some forest species. Its stomata apparently close very slowly in response to even large changes in the water-content. These facts suggest that the water-content of its leaves must be subject to very considerable variation, and that, during the dry season, it must be greatly reduced without any serious injury to the tree as a whole. Previous work on the aeration system of these plants (4) had, indeed, indicated that considerable changes in the water-content did take place in response to seasonal changes. In this work the size of the intercellular space system was measured by injecting the leaf with 4 per cent. alcohol and determining the increase in weight. A sharp contrast was noticed between results obtained during the hot, dry weather and low results during rainy weather. The explanation of this was found to be that the fluid injected into the leaf fills not only the intercellular spaces, but is also absorbed by the cells of the leaf. When the water-content of the cells is low more of the injection fluid is, of course, absorbed, and consequently high results are obtained for the apparent value of the intercellular space system. In the case of *Ptaeroxylon utile* the results are found to vary from 15.59 per cent. to 56.62 per cent., and in the case of *Portulacaria afra* from 21.04 per cent. to 73.43 per cent.

Knight's recent work (8) has shown that the water content of leaves apparently similar may differ by as much as 2 per cent., or even more, but that the difference between two companion leaves at the same node or between two opposite leaflets of a pinnate leaf is much smaller. Before proceeding therefore to investigate the seasonal changes in water-content it was necessary to determine the extent of the variation between similar leaves or leaflets at any given time. For this purpose a single leaf of *Ptaeroxylon utile* was taken and the water-content of each leaflet determined in the usual way. Two leaflets were also taken from a leaf opposite to the first and a pair of leaflets from each of the two leaves immediately below. The results are shown in Table XV.

TABLE XV.

Water-content of Single Leaflets of Ptaeroxylon utile. *A and B indicate opposite leaves or leaflets.*

Leaf No.	Leaflet No.	Water-content per cent. Fresh Weight.
1 A.....	1A	63·51
	1B	64·22
	2A	63·78
	2B	64·34
	3A	63·81
	3B	63·83
	4A	63·86
	4B	63·63
	5A	64·22
	5B	63·71
	6A	64·55
	6B	64·13
1 B.....	2	64·34
	4	64·27
2 A.....	2A	64·31
	2B	64·07
2 B.....	2A	64·10
	2B	64·00

Evidently the water-content of leaflets on the same leaf or shoot does not vary by more than about 1 per cent., while the difference between opposite leaflets is in no case greater than 0.75 per cent. Several similar experiments confirmed this result. In studying the seasonal variation it was therefore decided to adopt the following procedure:—Zinc labels were fastened by means of light wire to the leaves selected for the water-content determinations, and the leaflets were removed from these in the following order: (1) 1A, (2) 1B and 2A, (3) 2B and 3A, and so on. In this way any change in the water-content during the period elapsing between two successive determinations will be measured by the difference between opposite leaflets.

In the case of *Portulacaria afra* a single shoot was taken and the water-content of each individual leaf was determined, the leaves being numbered from the base upwards. The young leaves at the top of the shoot were not included. Table XVI is typical of a number of experiments.

TABLE XVI.

Water-content of Single Leaves of Portulacaria afra. *A and B are opposite.*

Leaf No.	Water-content per cent. of Fresh Weight.
1A.....	89·23
1B.....	88·28
2A.....	88·16
2B.....	88·92
3A.....	88·33
3B.....	89·30
4A.....	88·24
4B.....	88·37
5A.....	88·92
5B.....	89·25
6A.....	89·19
6B.....	88·84

In this case the difference between the minimum and the maximum water-content of the leaves examined is just over 1 per cent., while the difference between opposite leaves is never greater than 1 per cent. For the investigation of the seasonal change in water-content a procedure exactly similar to that already described for *Ptaeroxylon utile* was followed.

In connexion with these determinations of water-content several experiments were made to discover how far the water-content of the leaves on the tree fell below the water-content when they had been rendered fully turgid. To do this, leaves or leaflets were picked from the tree, placed in a weighing bottle, and weighed They were then placed in a small beaker of water for a period of at least four hours and then weighed again. Finally, the dry weight was determined.

The first experiment was conducted with leaves of *Portulacaria afra*, which are small, thick, and fleshy. A shoot was picked and placed in water and two leaves were detached and weighed, and then left in water overnight and weighed again next morning. The opposite leaves were left attached to the twig, which was kept in water under a bell-jar, and were removed the following morning and weighed and dried. This was to determine whether this second method of increasing the water-content was as effective as the first. The results of this experiment are given below.

TABLE XVII.

Experiment to Determine the "Water Deficit" of Leaves of Portulacaria afra. *5th February*, 1923.

Number of Leaf.	1A.	2A.
	Gms.	Gms.
Weight of leaf when picked	0·5290	0·5550
Weight of leaf after floating on water	0·5725	0·6192
Dry weight of leaf	0·0456	0·0546
Water-content of turgid leaf	0·5269	0·5646
Water-content when picked	0·4834	0·5004
Water-content when picked per cent. of water-content of turgid leaf	91·75 %	88·60 %
"Water deficit"	8·25 %	11·26 %

The opposite leaflets 1B and 2B were left on the twig overnight. The following results show that this leads to an equal increase in the water-content as when the leaves are placed directly in water.

TABLE XVIII.

Number of Leaf.	Water-content of Fully Turgid Leaf. Fresh Weight of Fully Turgid Leaf.
	Per cent.
1A (placed in water)	92·03
1B (left on twig)	92·12
2A (placed in water)	91·18
2B (left on twig)	92·54

A similar experiment was also carried out with leaflets of *Ptaeroxylon utile*.

TABLE XIX.

Experiment to Determine the "Water Deficit" of Leaflets of Ptaeroxylon utile. *5th February*, 1923.

Number of Leaflet.	1A.
	Gms.
Weight of leaflet when picked.....	0.1381
Weight of leaflet after floating on water.....	0·1406
Dry weight of leaflet.....	0·0523
Water-content of turgid leaflet.....	0·0883
Water-content when picked.....	0·0858
Water-content when picked per cent. of water-content of turgid leaf.....	97·16 %
"Water deficit".....	2·84 %

The opposite leaflet was left on the twig standing in water under a bell-jar overnight.

TABLE XX.

Number of Leaflet.	Water-content of Fully Turgid Leaflet. Fresh Weight of Fully Turgid Leaflet.
	Per cent.
1A (placed in water).....	62·8
1B (left on twig).....	62·1

These two experiments show that even during the rainy season, the leaves of these two plants may have a water-content below the maximum possible when they are fully turgid. Considering that the plants from which these leaves were taken were growing quite near to one another it is rather surprising to find that the leaves of *Portulacaria afra* have a greater "water deficit" than those of *Ptaeroxylon utile*, especially in view of the fact that the former have been shown to be more resistant to water loss than the latter. The possibility is suggested that where absorption is increased and transpiration decreased the cell-walls become very much distended. The degree of extensibility of the cell-walls may vary in different leaves, and therefore what we have termed the "water deficit" may not be strictly comparable in different cases. For example, one might expect a greater distension of the cell-walls in a soft, fleshy leaf such as that of *Portulacaria afra* than in a somewhat sclerenchymatous one such as that of *Ptaeroxylon utile*.

This possibility is very clearly shown by the following experiment. Certain results seemed to indicate that the "water deficit" varied with age of the leaf. A young twig of *Portulacaria afra* was therefore taken and the leaves detached from the apex downwards and weighed. They were then placed in water overnight and reweighed next morning, and then dried in a steam-oven. The same procedure was followed with a twig of *Ptaeroxylon utile*, leaflets being taken from successively older leaves. The results are shown in Table XXI.

TABLE XXI.

The "Water Deficit" of Leaves of Different Ages of Portulacaria afra *and of* Ptaeroxylon utile. *7th February*, 1923.

Leaf Number.	*Portulacaria afra.*		*Ptaeroxylon utile.*	
	Water-content of Leaf when Picked, per cent. of Water-content when Fully Turgid.	Deficit.	Water-content of Leaf when Picked, per cent. of Water-content when Fully Turgid.	Deficit.
1 (youngest)	70·68	29·32	80·48	19·52
2	88·86	11·14	92·81	7·19
3	86·22	13·78	94·07	5·93
4	86·08	13·92	—	—
5	92·45	7·55	—	—
6	96·29	3·71	—	—
7 (oldest)	94·30	5·70	—	—

In each case it will be noticed that the "water deficit" shows a very marked decrease as the leaves get older. The most feasible explanation of this seems to be that in the young leaves the cell-walls are far more extensible than in the older ones, and any process which retards transpiration and facilitates absorption will result in a greater stretching of the cell-walls in the young leaves than in the old leaves. Consequently the water-content of the leaf, after it has been subjected to such treatment, is far greater than is necessary for the maintenance of the usual degree of turgor. This is in agreement with the conclusion drawn by Knight from his recent work on wilting (8) that the cell-wall is only very slightly distended in the normal turgid state of the cell, since a very small reduction in the water-content is sufficient to cause visible flaccidity. The usual methods of increasing the turgidity to a maximum result in distending the cell-walls of the young leaves to a greater extent than occurs under natural conditions.

Since the above results were obtained in February, in the middle of the rainy season, when the water-content, as will be shown later, reaches its maximum, they suggest that even in fully mature leaves a certain amount of abnormal stretching of the cell-walls may occur when the leaves are treated as has been described. At the same time it must be noted that results have been obtained with the leaves of both *Portulacaria afra* and *Ptaeroxylon utile*, which show that their water-content when picked may sometimes be as high as 96 to 98 per cent. of the maximum possible water-content.

A.—The Diurnal Variation in Water-content of the Leaves of Ptaeroxylon utile.

Several experiments were carried out to determine the extent of the diurnal change in the water-content of the leaves. In an experiment with *Ptaeroxylon utile*, for example, three leaves at different heights on the tree were marked by means of zinc labels, and two leaflets were removed in the morning and weighed and then dried. In the afternoon the leaflet opposite one of those already picked was detached and similarly treated; the leaflet opposite the second of the two removed in the morning remained on the tree until the following morning. It was expected that there would be a decrease in the water-content during the day, followed by an increase again at night. Table XXII shows the results actually obtained.

Table XXII.

To Show the Diurnal Variation in the Water-content of Leaflets of Ptaeroxylon utile.

Leaf Number.	Leaflet Number.	Time When Picked.	Water-content per cent. of Fresh Weight.
1. Near base of tree.....	2A.....	9.40 a.m., 4/9/1923	52·59
	2B.....	2.50 p.m., 4/9/1923	52·95
	6A.....	9.50 a.m., 4/9/1923	52·81
	6B.....	9. 0 a.m., 5/9/1923	52·77
2. Half-way up tree.....	2A.....	10.0 a.m., 4/9/1923	51·99
	2B.....	3.0 p.m., 4/9/1923	51·52
	4A.....	10.10 a.m., 4/9/1923	50·42
	4B.....	9.10 a.m., 5/9/1923	51·45
3. Near top of tree.....	2A.....	10.15 a.m., 4/9/1923	51·25
	2B.....	3.10 p.m., 4/9/1923	52·13
	4A.....	10.25 a.m., 4/9/1923	50·89
	4B.....	9.35 a.m., 5/9/1923	50·90

From these figures it is clear that any diurnal variation in the water-content must be very slight, since in no case is the difference between opposite leaflets greater than 1 per cent. The experiment was begun rather late in the morning, however, and it was thought that possibly a more pronounced difference would be found if the first reading were taken earlier. The following experiment with a single leaf will illustrate this.

Table XXIII.

To Show the Diurnal Variation in Water-content of Leaflets of Ptaeroxylon utile.

Leaflet Number.	Time when Picked.	Water-content.	Difference.
		Per cent.	Per cent.
2A.....	7.15 a.m.....	47·64	
			— 1·49
2B.....	9.45 a.m.....	46·05	
			— 0·21
3A.....	10. 0 a.m.....	45·48	
3B.....	2.30 p.m.....	45·27	
			— 0·05
4A.....	2.40 p.m.....	44·35	
4A.....	5. 0 p.m.....	44·30	

In this case the difference between the first two leaflets (2A and 2B) is distinctly greater than usually occurs between two opposite leaflets, and this probably indicates a real, though very slight, reduction in the water-content. Further, the difference between 2A and either 4A or 4B is over 3 per cent., and it has been previously shown that the leaflets of a single leaf do not vary by more than 1 per cent. It seems probable, therefore, that there is a slight diurnal variation in the water-content, but that this can only be detected by beginning the determinations very early in the morning. In view of this, the leaflets used in the determination of the seasonal variation in the water-content were always picked at about the same time each day. Both these experiments on the diurnal variation were conducted towards the end of the dry season, when the water-content of the leaves is low. There is a possibility that during the rainy season the diurnal variation is greater than is indicated here, but this has not yet been investigated.

B.—The Seasonal Variation in the Water-content of the Leaves of Ptaeroxylon utile *and* Portulacaria afra.

For this investigation two trees of *Ptaeroxylon utile* and one of *Portulacaria afra* were selected. On each of the former two leaves were marked by the attachment of zinc labels, and on the latter two shoots were similarly marked. As already explained, two leaflets or two leaves were taken for each water-content determination. The record was commenced during July, in the middle of the dry season, when the water-content might be expected to be at its minimum. In a normal season the rains would have commenced late in August or early in September, but this year proved exceptional, the dry season being prolonged until late in October. All over the country the drought was exceptionally prolonged and severe. The results obtained are therefore of special interest, since they probably indicate very nearly the maximum variation in water-content likely to occur in these particular trees. Tables XXIV-XXVII show these results. In the case of each leaf there is given in the first column the number of the leaflets, in the second the water-content expressed as a percentage of the fresh weight, in the third the difference between successive determinations, and in the fourth the water-content of the leaf when picked expressed as a percentage of the water-content when the leaf is fully turgid.

TABLE XXIV

Showing the Seasonal Variation in Water-content of the Leaflets of Ptaeroxylon utile. *Tree No.* 1.

Date.	Leaf No. 1.				Leaf No. 2.			
	Leaflet No.	Water-content.	Difference.	Water when Picked, per cent. Water when Turgid.	Leaflet No.	Water-content.	Difference.	Water when Picked, per cent. Water when Turgid.
				Per cent.				Per cent.
23/ 7/23	1B	49·57	—	88·28	—	—	—	—
24/ 7/23	2A	48·28	−1·15	—	1A	48·33	−0·82	—
1/ 8/23	2B	47·13		84·65	1B	47·51		85·33
	3A	47·18	+0·50	85·31	2A	45·80	+1·44	84·68
6/ 8/23	3B	47·68		87·72	2B	47·24		85·53
	4A	48·10	−0·94	89·84	3A	47·34	−1·93	87·60
20/ 8/23	4B	47·16		—	3B	45·41		—
	5A	46·62	−0·19	—	4A	46·10	−0·50	—
28/8/23	5B	46·43		—	4B	45·60		—
	6A	46·34	−0·83	—	5A	45·75	+0·08	—
17/9/23	6B	45·51		—	5B	45·83		—
	7A	45·69	−0·50	—	6A	44·80	+0·17	—
29/ 9/23	7B	45·19		—	6B	44·97		—
	1A*	45·30	−0·01	—	7A	44·63	−1·87	—
8/10/23	1B	45·29		—	7B	42·76		—
	2A	47·01	+2·16	—	2A*	45·58	+4·58	—
31/10/23	2B	49·17		—	2B	50·16		—
	3A	49·52	−5·06	—	3A	49·17	+5·53	—
23/11/23	3B	55·12		—	3B	54·70		—

* Zinc label transferred to neighbouring leaf.

From this table it will be seen that towards the end of July the water-content of leaflets from both leaves was approximately 48 per cent. In order to gain some idea at once whether this represented a marked decrease from the highest possible water-content, some of the leaflets were kept in water for some hours after they had been picked and the increase in the water-content determined. In this way the "water deficit" could be calculated, and, as will be seen from the fourth column, this amounted to 12 or 15 per cent. This "water deficit," however, was found to vary somewhat irregularly.

For example, in the second leaf above, leaflets Nos. 2B and 3A differ by only 0.10 per cent. in their water-content, but their "water-deficit" differs by nearly 2 per cent. In view of this, these determinations were discontinued.

From the end of July until the 8th of October there is a steady, though slow, lowering of the water-content. The differences between opposite leaflets in the successive determinations were never very marked, but if we compare in each leaf leaflet No. 7B with No. 1A we find a difference in the first case of 4.38 per cent., and in the second of 5.57 per cent. These differences are considerably greater than normally occur between leaflets of the same leaf, and must indicate a real diminution of the water-content. Between the 8th of October and the 31st the drought broke, and towards the end of the month heavy rains fell. This is reflected in the above results by a pronounced rise in the water-content, amounting in one case to 2 per cent. and in the other to 4.5 per cent. More rain fell in November, and this resulted in a still more pronounced rise in the water-content of the leaves. During the two rainy months of October and November the total rise in the water-content appears to have been approximately 10 per cent. Such figures as these show that the leaves of *Ptaeroxylon utile* are able to withstand a considerable reduction of their water-content without any ill-effects. The leaves showed no very marked wilting, though one could detect a certain degree of flaccidity just before the rains came. Further, they are able to survive even though their water-content remains low for some months. It is true that in the case of this particular tree a number of the leaves did not recover from the effects of the drought, but withered and died even after rains came. These, however, were few in number, and did not include either of the leaves used in this investigation. This fact, however, suggests that a slightly greater lowering of the water-content than is shown in Table XXIV would have resulted in the death of the leaves. Whether it would also result in the death of the tree is another question. Probably once the water-content is lowered to a certain point the leaves die and are shed, but once the rains come new shoots are formed.

TABLE XXV.

Showing the Seasonal Variation in the Water-content of the Leaves of Ptaeroxylon utile. *Tree No. 2.*

Date.	Leaf No. 1.				Leaf No. 2			
	Leaflet No.	Water-content.	Difference.	Water when Picked, per cent. of Water when Turgid.	Leaflet No	Water-content.	Difference	Water when Picked, per cent. Water when Turgid.
26/7/23..	1A	54·17		98·26	1A	53·15		95 74
			− 3·30				3 55	
21/8/23..	1B	50·87		—	1B	49·60		—
	2A	50·67			2A	49·94		
			3·11				3 21	
30/8/23..	2B	53·78		—	2B	53 15		—
	3A	54·19			3A	52 89		
			− 2·83				2 57	
17/9/23..	3B	51·36		—	3B	50 32		—
	4A	50·67			1A	49 91		
			+ 0·26				0 41	
29/9/23..	4B	50·93		—	1B	50 32		—
	5A	50·17			5A	50 34		
			− 1·13				—	
8/10/23..	5B	49·04		—				
	6A	49·99		91·26	1A*	49 23		
			+ 0·96				1 99	
31/10/23.	6B	50·95		—	1B	51·22		—
	7A	50·47			2A	51·18		
			+ 1·87				+ 4 92	
23/11/23.	7B	52·34			2B	56·10		—

* Zinc label transferred to neighbouring leaf.

The leaves of this tree present a remarkable contrast to those of the first. At the end of July their water-content is still high (53 to 54 per cent.), and their " water deficit " is in one case less than 2 per cent. and in the other less than 5 per cent., indicating that their water-content is very nearly at its maximum. There is no steady diminution in the water-content, but rather marked fluctuations occur between the successive determinations. As in the previous case, the water-content does reach its lowest point (approximately 49 per cent.) about the beginning of October, and rises again during October and November. The increase, however, is less pronounced and amounts to at most 3 per cent. in one case and 7 per cent. in the other.

The differences between the two trees are probably due to the fact that they are growing in different situations. The first is growing at the foot of the college drive on the left. The second is about half-way up the drive on the other side. Inquiries elicited the fact that just above this second tree was a large french-drain, into which all the water running off from the college passed. This tree was therefore growing under very favourable conditions as regards soil moisture, and consequently the water-content of the leaves did not fall to any great extent. Further, any slight rainfall would be likely to have quite a considerable effect upon a tree in such a situation, and this probably accounts for the fluctations in the water-content.

TABLE XXVI.

Showing the Seasonal Variation in the Water-content of the Leaves of Portulacaria afra.

Date.	Shoot No. 1.				Shoot No. 2.			
	Leaf No.	Water-content	Difference.	Water when Picked, per cent. of Water when Turgid.	Leaf No.	Water-content.	Difference.	Water when Picked, per cent. of Water when Turgid.
24/7/23..	7A	91·05	−1·19	—	3A	90·42	−0·10	95·74
1/8/23..	7B	89·86		98·47	3B	90·32		—
	8A	89·82	−0·02	96·77	5A	89·17	+1·46	—
6/8/23..	8B	89·80		95·66	5B	90·63		—
	9A	90·24	−0·83	98·31	6A	91·28	−2·93	—
21/8/23..	9B	89·41		—	6B	88·35		—
	10A	89·28	−0·26	—	8A	88·59	+0·66	—
3/9/23..	10B	89·54		—	8B	89·25		—
	11A	89·06	−2·00	—	9A	89·19	−5·34	—
8/10/23.	11B	87·06		—	9B	83·85		—
	12A	86·66	+3·05	—	12A	85·53	+2·13	—
23/11/23.	12B	89·71		—	12B	87·66		—

In this case it should be noted that even at the beginning of August the water-content of the leaves is still high, and, judging by the figures in the fourth column, is practically at its maximum. Practically no change can be detected in this water-content right through the following month. Between the 3rd of September and the 8th of October, however, there is a distinct drop in the water-content, amounting to 2 per cent. in one case and 5 per cent. in the other. Following upon the rains during October the water-content rose by between 2 and 3 per cent. There is thus considerably less variation in the water-content of the leaves of this tree than in those

of the *Ptaeroxylon utile* trees studied, and it is worth noting that at the time that the water-content reached its minimum the leaves had a distinctly "flabby" appearance.

An interesting comparison may be drawn between the leaves of *Portulacaria afra* and those of *Ptaeroxylon utile*. In Table XXIV it has been shown that by the middle of the dry season, that is, in July, the leaves of *Ptaeroxylon utile* had a water-content much below what they have in the summer. The long drought caused a further lowering of this water-content, but once the drought was broken the water-content rose considerably higher than it had been even in July. In the succulent leaves of *Portulacaria afra*, on the other hand, the water-content does not appear to have been much below its maximum even in July, and there was only a very small reduction in the water-content during August and September. By the beginning of October, however, there had been a distinct drop in the water-content amounting to about 5 per cent. Following upon the rains the water-content again rose practically to what it had been in July. There are two possible explanations of these differences. One is that the situation in which the two plants are growing is different. How great an effect this may have has already been shown in the case of the second tree of *Ptaeroxylon utile*. Here, however, there was a well-marked artificial cause producing the difference, and, as far as is known, no such cause was operative to effect a marked difference between the situations in which the first tree of *Ptaeroxylon utile* and the tree of *Portulacaria afra* were growing. It seems probable, therefore, that the difference in the water-content of the leaves of these two trees is due to differences in the character of the leaves themselves. The leaves of *Portulacaria afra* are small, thick, and fleshy, and, in the first part of this paper, we have shown that they lose water very slowly when drying in comparison with the thinner and more sclerophyllous leaves of *Ptaeroxylon utile*.

This would probably account for the fact that they maintain a high water-content even during a long period of drought. In the absence of definite evidence as to the close similarity of the two situations in which these plants are growing it would be unwise to make any generalization as to the comparative behaviour of the leaves of these trees during the dry season.

Probably the only way of making a really satisfactory comparison of the two plants is by working with potted plants. Unfortunately, young plants of *Ptaeroxylon utile* are not easily obtained, and none of a suitable age were available. *Portulacaria afra*, on the other hand, grows easily from shoots, and several potted plants were easily obtained. An experiment was carried out with one of these as follows:—The plant was kept in the greenhouse and was well-watered for several days. At 10.30 a.m. on the 5th of September it was finally watered. Two leaves from a marked shoot were then picked, weighed, and dried. The following morning the leaf, opposite one of those already removed, was also picked, weighed, and dried. The plant was then placed on the laboratory roof and left unwatered until the 29th of September, by which time the leaves had a distinctly flaccid appearance and several were beginning to fall. The leaf opposite the second of those originally picked was then removed and its water-content determined. The results are shown in Table XXVII.

TABLE XXVII.

Showing Variation in Water-content of the Leaves of a Potted Plant of Portulacaria afra.

Shoot No.	Leaf No.	Date when Picked.	Water-content.	Difference.
			Per cent.	Per cent.
1.....	3A	5th September, 1923.....	91·64	—
	3B	6th September, 1923.....	91·01	—
	4A	5th September, 1923.....	91·26	} 2·75
	4B	29th September, 1923.....	88·51	
2.....	2A	5th September, 1923.....	90·31	—
	2B	6th September, 1923.....	90·22	—
	4A	5th September, 1923.....	90·76	} 2·48
	4B	29th September, 1923.....	88·28	

The plant in this experiment was placed under very severe conditions. The soil in the pot soon became very dry and the plant was fully exposed to a hot sun and the very dry atmosphere. Yet, after twenty-three days, the water-content of the leaves had only fallen by 2.5 per cent. This reduction of the water-content, however, resulted in distinct flaccidity of the leaves.

III.—General Discussion.

The results obtained in the preceding study of the seasonal variation of the water-content of the leaves of *Ptaeroxylon utile* are probably indicative of what usually takes place in most plants growing in the low veld during the winter months. Except in cases where the leaves are extremely retentive of water a pronounced decrease in the water-content is likely to occur during the dry season. In what may be termed true low-veld plants, this has probably led to the adoption of a deciduous habit, and many of these trees lose their leaves fairly regularly each year. Forest trees are more tropical and are usually evergreen. In this connexion it is interesting to compare certain of the trees actually studied.

Cordia caffra is a typical low-veld tree occurring abundantly in the thorn veld. As we have seen, its leaves lose water very rapidly when they are drying, and hence we have concluded that they have little power of checking transpiration even when their water-content is falling. The wood, however, allows water to pass through it fairly rapidly. Consequently, as long as there is a fair supply of water in the soil, the leaves are able to obtain all the water they require. Once the dry weather begins the moisture-content of the soil falls, and even though water can pass rapidly upwards it can only be obtained with difficulty. Under these circumstances it is difficult to see how the water-content of the leaves can be maintained, and, sooner or later, the leaves are shed.

Forest species such as *Xymalos monospora* grow in situations where the water-content of the soil remains high right through the year, and consequently there is always plenty of water available for them. Their wood may in some cases transmit water very slowly, but there is usually associated with this a considerable power of retarding water loss on the part of the leaves. Consequently it seems highly probable (though we have not at present any experimental evidence) that the leaves of such trees never suffer any very large reduction of their water-content and their leaves are retained for more than a year.

Ptaeroxylon utile is particularly interesting as an example of a forest species which is able to grow successfully in the low veld. Its leaves are less resistant to water loss than are those of *Xymalos monospora*, but far more resistant than those of *Cordia caffra*. Its wood, however, transmits water very slowly. This renders a decrease in the water-content of the leaves almost inevitable as soon as the dry season begins. The tree, however, still retains its evergreen character and is evidently able to pass through several months of the year with the water-content of its leaves very much below its full amount. It is very difficult to see how the leaves are able to survive such a long period of lowered water-content without any marked signs of wilting and withering. Probably the presence of fairly large amounts of sclerenchyma in the leaves may account for the maintenance of their rigidity.

It is interesting to compare the results obtained in this work with those obtained by other investigators. Knight (8), working with plants in south-eastern England, found that the diurnal change in leaf water-content amounted to less than 2 per cent., but did not study the seasonal change. Clark (6), working with certain trees in Pennsylvania, found a large seasonal change and also a diurnal change, amounting in one case to 20 per cent. Knight suggests, however, that in these experiments the leaves used for water-content determinations were never really comparable at all, but differed very considerably at the outset. Livingston and Brown (10), working with desert plants, found a diurnal variation in the leaf water-content of 1 to 8 per cent. The present work has shown that the diurnal variation in the water-content of the leaves of *Ptaeroxylon utile* is small in the dry season, amounting to at most 2 per cent. The seasonal variation, on the other hand, is large, and in one case amounted to as much as 10 per cent.

Several further lines of work are suggested. For one thing, it would be interesting to compare the diurnal change of water-content in leaves of *Ptaeroxylon utile* and other plants in the dry and the wet seasons. Another suggestion is to compare the rate of loss of water during drying in the two seasons. It may be that with the lowered water-content in the dry season the leaves become more resistant to water loss, owing either to the stomata closing down somewhat or to the formation of substances more retentive of water. Probably these experiments could best be carried out by working with potted plants under carefully controlled conditions, and as soon as these are available it is hoped to follow up some of these suggestions.

Summary and Conclusions.

1. A brief account is given of the principal plant communities of the midlands of Natal, and it is concluded that the physical differences between them are likely to have a considerable effect upon the water relations of the plants composing them.

2. A method of determining the "water-retaining power" of the leaves of plants is described and an account given of the application of this method to a number of plants. From these results it is possible to arrange the leaves in the order of their ability to retain water. This, however, is not considered sufficient evidence of the relative xerophytism of the plant as a whole.

3. Two forest species, *Podocarpus henkelii* and *Xymalos monospora*, are found to have leaves which are very resistant to water loss.

4. These trees also possess wood of very low water-conducting power, and it is considered that this probably accounts for the xerophytic character of the leaves.

5. Leaves which lose water rapidly during drying appear to be associated with wood of high water-conducting power.

6. *Ptaeroxylon utile* is somewhat peculiar in that its leaves frequently show a high rate of water loss, although its wood transmits water very slowly.

7. The leaves of *Ptaeroxylon utile* vary very considerably in their rate of water loss. This variation does not appear to be connected with the position of the leaf on the tree. Age of the leaf has a considerable effect upon the rate of loss, but this is not considered to afford a complete explanation of the variation found.

8. Stomatal closure appears to take place very slowly in the leaves of *Ptaeroxylon utile* in response to a diminishing water-content.

9. A study is made of the changes in the water-content of the leaves of *Ptaeroxylon utile* and *Portulacaria afra*.

(*a*) The diurnal change in the water-content of the leaves of *Ptaeroxylon utile* is found to be very small.

(*b*) The seasonal change in the water-content is more marked. In one case a variation of 10 per cent. in the leaves of *Ptaeroxylon utile* was found and a change of 5 per cent. in the leaves of *Portulacaria afra*.

(*c*) In the dry season these leaves contain considerably less water than they are capable of containing at the time.

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SECTION II.

The Water-retaining Capacity of Certain Woods in Relation to their Microscopic Structure.

Introduction.

From the results obtained in these investigations on the physiology and ecology of Natal plants, and set forth in the first series of papers (Botanical Survey Memoir No. 5), as well as in the first section of this Memoir, it has become increasingly obvious that it is very

difficult to determine relative degrees of xerophytism in terms either of general morphology or of special functions. The plant has to be considered as a whole as regards its form and structure and physiological behaviour, and conclusions must be drawn with caution from special studies of one function or of the functional activities of one organ, even of such an important organ as the leaf. Perhaps one of the chief weaknesses of most physiological researches in the past is that they have been of too specialized a nature; they have dealt in too isolated a way with single functions; they have not considered the organism as a whole. We have seen, for instance, that two important and often dominant forest trees in Natal, *Podocarpus henkelii* and *Xymalos monospora*, which grow in the moistest type of habitats, and from the standpoint of distribution and a general ecological analysis of the plant communities would be classified as mesophytic or even hygrophilous, have leaves that are resistant to water loss, and from this standpoint would be classed as distinct xerophytes.

Further, it has been shown that they possess wood of very low water-conducting power, and it is inferred that this fact is to be correlated with the power possessed by their leaves of resisting water loss. *Xymalos* particularly is never found in even moderately dry situations, but it often takes complete possession of the wetter parts of the forest, ousting everything else. It is a tree of very heavy foliage and casts such a dense shade that no other species can live underneath it. Yet it pumps up water very slowly and its leaves retain their water and control their water loss very efficiently.

On the other hand, typically "xerophytic" trees, like the various eucalypts that are now so widely and abundantly cultivated in Natal, can grow isolated in quite dry situations and fully exposed to the scorching effects of hot winds, yet their leaves lose water readily and they pump up water quickly. To drain a marsh one does not plant "hygrophilous" species like *Xymalos*, but "xerophytic" trees like the eucalypts. Since the water-conducting power of the wood has been shown to be important, it was thought that information of value might also be obtained by investigating the water-retaining power of freshly-cut samples of the wood as they dry out. The results obtained have shown that the total length of time taken in drying bears little relationship to the water-conducting power of the wood. The latter presumably depends chiefly on the characters of the larger vessels which dry out quickly, while the further drying of the wood depends on the single cell elements of the xylem, the wood fibres, and tracheids. While the observations made have in themselves a certain practical or economic importance in connexion with the seasoning of timbers, our primary purpose has been to attempt some sort of correlation between the rates of drying out and the microscopical structure of the woods.

Though these attempts have been only partially successful, and much work remains to be done, yet certain interesting hypotheses are suggested by the results obtained, and the whole work is of sufficient interest to justify the publishing of this condensed preliminary account.

Experimental Methods and Results.

Altogether, the woods of twelve indigenous Natal species and nineteen exotic Australian (eucalypt) trees were examined.* The

*The specimens were obtained through the courtesy of Mr. J. J. Boocock, Conservator of Forests for Natal, to whom our thanks are due.

specimens consisted of pieces, more or less of a uniform size, one square inch in cross-section and about two inches long, cut from the older wood of trees that had been newly felled and taken from the base of the trunk, a foot or two above the level of the ground. The pieces of wood were transported to the laboratory in an air-tight tin.

The woods were weighed in a definite order and placed in a steam drying-oven, being dealt with for convenience in three separate series. The separate intervals given in the steam-oven between each re-weighing were the same for each specimen, until three successive weighings showed no further loss of weight.

It was found necessary to allow intervals for cooling before re-weighing, during which a certain loss of moisture continued. To minimize the effect of this source of error as far as possible, these intervals were made the same for each specimen, so that, while not individually strictly accurate, the results remain comparable. In further work on this subject it is intended to weigh the specimens after they have been allowed to cool in special closed receptacles of known weight.

The times of drying given in the following tables are the totals of the times in the steam-oven. In the expression of results the losses could not be shown as percentages either of the initial or of the final weights of the specimens, since these varied somewhat in size and very considerably in density. As in the case of the drying out of leaves, the most satisfactory method is to take the total water loss or water-content of the specimens as 100 and the amounts lost after definite intervals of time as percentages of this total.

TABLE I.

(Indigenous Species.)

Name.	Total Percentage of Weight Lost.	Percentage of Original Water-content remaining after Drying for									Total Time of Drying in Hours.
		0 hour.	1 hour.	2 hours.	3 hours.	10 hours.	20 hours.	30 hours.	40 hours.	50 hours.	
1. *Cussonia spicata*.....	70·68	100	78	69	64	20	3·5	2·1	0	0	35
2. *Podocarpus henkelii*..	66·82	100	89	63	58	5	1·5	1·0	0	0	37
3. *Xymalos monospora*..	54·28	100	66	57	53	11	2·5	1·4	0	0	38
4. *Rapanea melanophleos*	51·16	100	86	77	68	9	2·5	0·7	0	0	37
5. *Ocotea bullata*.....	49·89	100	65	55	50	8	2·8	1·5	0	0	39
6. *Kiggelaria africana*..	46·58	100	83	74	70	25	6·9	2·5	0·6	0	48
7. *Calodendron capense*..	41·54	100	70	60	56	10	5·0	2·5	0·5	0	46
8. *Royena lucida*.....	39·99	100	80	71	60	15	5·5	2·8	0·9	0	49
9. *Fagara davyi*.....	34·56	100	67	58	53	11	3·0	1·5	0·1	0	41
10. *Celtis rhamnifolia*....	34·33	100	76	64	59	12	4·0	1·7	0	0	40
11. *Scolopia mundii*.....	33·09	100	81	68	56	10	3·5	1·5	0	0	40
12. *Ptaeroxylon utile*.....	27·23	100	72	65	61	28	13·0	7·0	4·5	1·1	59
AVERAGE.....	45·85	100	76	65	59	14	4·5	2·2	0·5	0·1	42

The species dealt with in Table I are all forest trees which were cut from the same forest—a midland mesophytic forest—and grown under more or less the same environmental conditions. If trees had been selected from different forests or from thorn veld in the case of those which, like *Ptaeroxylon*, also occur outside the forest, then the range of variation would have been probably much greater.

The amounts of water lost during the first three hours of drying vary greatly in the different species. *Kiggelaria africana* at the end of the interval shows the smallest loss, 30 per cent., while *Ocotea*

bullata has lost the most, 50 per cent. The gymnospermous *Podocarpus henkelii* loses 42 per cent. of its moisture in three hours, thus apparently behaving like the dicotyledonous trees. But for the first hour it loses least of all, only 11 per cent., as compared with 35 per cent. in the case of *Ocotea bullata*, and 34 per cent. in the case of *Xymalos monospora*. *Podocarpus* shows rather a remarkable increase in the rate during the second hour. At the end of ten hours it has lost 95 per cent. of its original moisture, which is more than any of the others, and it dries out completely in thirty-seven hours, which is shorter time than that taken by all the dicotyledons, with the solitary exception of the very soft-wooded *Cussonia spicata*.

The low rate of water loss in *Podocarpus* during the first hour may be correlated with the absence of vessels, but it is significant that after the first hour *Podocarpus* loses water relatively more quickly than the dicotyledons. Probably, at the temperature of the steam-oven, most of the water contained in the lumina of the vessels in all the specimens would evaporate in one hour or less, and it is this water which accounts for the high initial losses, e.g. 35 per cent in *Ocotea*, 34 per cent. in *Xymalos*, and 33 per cent. in *Fagara*. In this connexion, however, it is interesting to note that *Cussonia* is the softest timber, has the highest total water-content (70 per cent. of its original weight), and dries out in the shortest time (thirty-five hours), yet in the first hour it loses only 22 per cent., which is much less than many of the others.

Table I shows fairly clearly that, in a general way, trees with a high initial water-content reach complete dryness more quickly than those with a low. *Cussonia* and *Podocarpus*, at the head of the list, lose about 70 per cent. of their initial weight in drying, yet dry out quickly in thirty-five to thirty-seven hours. *Ptaeroxylon utile*, at the bottom of the list, loses only 27 per cent. of its weight, but takes fifty-nine hours' drying in the steam-oven before it does so. In the intermediate species, however, the correlation between initial water-content and time of drying out is not so exact. Probably the specimens varied a good deal in the amount of moisture which they contained at the time when the individual trees to which they belonged were felled, and it would be better to start the drying when the specimens have been saturated with water.

The softer woods dry out generally more quickly than the harder. Fourcade,* in his scale of hardness 0–10, places *Cussonia* as 2.1, *Podocarpus* 2.4–2.6, *Kiggelaria* 2.7, *Calodendron* 2.7, *Rapanea* 3.1, *Celtis* 4.0, *Royena* 4.0, *Ocotea* 4.3, *Scolopia* 5.0, *Fagara* 6.1, and *Ptaeroxylon* 8.0. Here, again, *Cussonia* and *Podocarpus* are distinctly the softest of all, and they dry out most quickly, while *Ptaeroxylon* is much the hardest and dries out most slowly, but the intermediate types are more irregular.

Density and hardness are more or less correlated. Fourcade's density figures are *Cussonia* 0.46, *Podocarpus* 0.47–0.59, *Calodendron* 0.62, *Kiggelaria* 0.65, *Rapanea* 0.72, *Celtis* 0.76, *Royena* 0.77, *Ocotea* 0.78, *Scolopia* 0.84–1.0, *Fagara* 0.94, *Ptaeroxylon* 1.09. *Cussonia* and *Podocarpus* are the lightest, while *Ptaeroxylon* is the heaviest. The experiments with indigenous woods indicate in a very general way that the lighter, softer woods with a high initial water-content lose water more quickly and dry out completely in a shorter time than heavy, dense, hard woods which contain less water to begin with, and therefore lose less weight in the process of seasoning.

* Fourcade, H.G., "Report on the Natal Forests." Government Blue-Book. Natal, 1889.

TABLE II.

(Exotic Species.)

Name.	Total Percentage of Weight Lost.	Percentage of Original Water-content remaining after Drying for									Total Time of Drying in Hours.
		0 hour.	1 hour.	2 hours.	3 hours.	10 hours.	20 hours.	30 hours.	40 hours.	50 hours.	
1. *Eucalyptus botryoides.*	54·00	100	89	80	72	32	4·3	0·5	0	0	37
2. *Eucalyptus robusta...*	53·22	100	95	86	78	43	12·0	2·0	0·5	0·1	52
3. *Eucalyptus obliqua...*	52·95	100	87	73	64	18	3·0	1·0	0	0	37
4. *Eucalyptus petiolaris.*	52·84	100	91	79	70	25	2·0	0·1	0	0	31
5. *Eucalyptus globulus..*	51·36	100	93	84	77	32	3·5	0·5	0	0	34
6. *Eucalyptus saligna...*	47·95	100	93	84	77	34	5·0	0·2	0	0	32
7. *Eucalyptus tereticornis*	46·89	100	94	86	79	47	18·0	4·0	1·3	0	48
8. *Eucalyptusamygdalina*	46·25	100	91	83	77	40	11·0	2·0	0·5	0	43
9. *Eucalyptus eugenioides*	41·03	100	92	82	74	38	14·0	4·0	1·0	0	45
10. *Eucalyptus resinifera.*	39·63	100	86	78	70	28	7·0	3·0	0·3	0	42
11. *Eucalyptus sideroxylon*	39·13	100	89	79	70	31	8·0	1·8	0	0	40
12. *Eucalyptus melliodora*	38·19	100	87	76	67	31	13·0	5·3	2·0	0	48
13. *Eucalyptus rostrata..*	38·02	100	88	80	71	33	7·0	2·5	0	0	40
14. *Eucalyptus leucoxylon*	37·66	100	94	76	67	28	7·0	2·0	0·6	0	46
15. *Eucalyptus sieberianus*	37·29	100	90	82	76	39	11·0	3·5	1·0	0	48
16. *Eucalyptus longifolia.*	36·75	100	88	77	70	32	8·0	2·0	0·5	0	47
17. *Eucalyptus cladocalyx*	35·82	100	89	81	75	42	14·0	3·0	1·0	0	49
18. *Eucalyptus hemiphloia*	29·93	100	89	79	72	39	15·0	4·5	0·7	0·1	51
19. *Eucalyptus paniculata*	26·71	100	87	72	63	28	11·0	3·8	1·0	0	50
AVERAGE.....	42·39	100	90	80	72	33	10·2	2·4	0·59	0·01	43

The species of eucalypt are generally considered to be more xerophytic than the indigenous forest species dealt with in Table I. The eucalypts grow under a wider range of conditions than the majority of the Natal forest trees, though among the latter are one or two very plastic types like *Ptaeroxylon*, which can withstand very dry conditions and grows also in the dry valley scrub. It is interesting therefore to compare the results in the two tables.

At the end of ten hours' drying in the steam-oven the eucalypt woods retain an average of 33 per cent. of their original water-content, while the indigenous species retain only 14 per cent. The eucalypts therefore dry out more slowly to begin with. The same feature is shown clearly by comparing the amounts lost at the end of the first, second, and third hours of drying. The eucalypts not only dry out more slowly at first, but the various species show greater uniformity in their rates. This may be due to the fact that they all belong to one genus, though there is a considerable range of variation in their total water-content. Though the initial rates of drying are slower, the total times taken to dry out completely are, on the average, very nearly the same for the eucalypts as for the indigenous species. The averages are forty-two hours for the indigenous and forty-three hours for the eucalypts.

As in the case of the indigenous species, the eucalypts, with a high initial water-content, in general dry out completely in a shorter time than those with a low initial water-content. There is, however, one notable exception among the nineteen examined, *Eucalyptus robusta*, the swamp mahogany of New South Wales. It is a tree which prefers wet localities. Among the other species, the correlation between total loss of weight and time of drying out is not a very exact one, but, on the whole, the smaller the total amount of water lost the longer it takes to dry out.

Until a larger number of samples of each species have been examined it is difficult to draw any general conclusions with certainty or to deduce anything from apparently exceptional behaviour on the part of one or two types.

Microscopic Structure and Water-retaining Power of the Wood.

It is reasonable to suppose that the initial loss of water during the first period of drying out depends, partly at least, on the size and character of the vessels, though, to test this fully, specimens completely full of water should be weighed, and not, as in the case of the species dealt with above, specimens cut from a newly felled tree. The larger vessels naturally part with their water first, and it is the finer xylem elements, the tracheids, and small fibres that are of importance in retaining water in half-dried wood. It was decided, therefore, to obtain these elements separately for examintion by macerating portions of the wood.

The macerating fluid consisted of chlorate of potash crystals dissolved in nitric acid, diluted sufficiently to slow down the action somewhat and thus obtain material soft enough for teasing out, but not too soft. During the process of maceration the material and fluid was warmed to the temperature of boiling water. The various lignified cell elements were examined separately and measured by means of a micrometer eye-piece, the average of numerous observations being taken in each case.

The measurements taken were (*a*) length, (*b*) external diameter, (*c*) thickness of wall, (*d*) internal diameter. These are set forth for the indigenous and exotic species separately in Tables III and IV.

Table III.

(*Indigenous Species.*)

Name.	Time taken to Dry in Hours.	Length of Elements in mm.	External Diameter in mm.	Wall Thickness in mm.	Internal Diameter in mm.
1. *Cussonia spicata*	35	1·259	0·053	0·0073	0·039
2. *Podocarpus henkelii*	37	1·902	0·026	0·0056	0·015
3. *Rapanea melanophleos*	37	0·646	0·028	0·0057	0·017
4. *Xymalos monospora*	38	1·287	0·034	0·0091	0·016
5. *Ocotea bullata*	39	1·084	0·024	0·0034	0·017
6. *Celtis rhamnifolia*	40	1·104	0·016	0·0043	0·007
7. *Scolopia mundii*	40	1·107	0·019	0·0072	0·005
8. *Fagara davyi*	41	1·131	0·017	0·0046	0·008
9. *Calodendron capense*	46	1·482	0·018	0·0040	0·010
10. *Kiggelaria africana*	48	1·127	0·026	0·0054	0·015
11. *Royena lucida*	49	0·812	0·015	0·0036	0·008
12. *Ptaeroxylon utile*	59	0·670	0·013	0·0030	0·007
Average	42	1·134	0·024	0·0053	0·014

Table IV.

(*Exotic Species.*)

Name.	Time taken to Dry in Hours.	Length of Elements in mm.	External Diameter in mm.	Wall Thickness in mm.	Internal Diameter in mm.
1. *Eucalyptus petiolaris*	31	0·955	0·019	0·0031	0·013
2. *Eucalyptus saligna*	32	0·807	0·015	0·0052	0·004
3. *Eucalyptus globulus*	34	0·760	0·010	0·0039	0·004
4. *Eucalyptus botryoides*	37	0·921	0·015	0·0045	0·006
5. *Eucalyptus obliqua*	37	0·973	0·012	0·0043	0·004
6. *Eucalyptus siderozylon*	40	0·712	0·013	0·0053	0·002
7. *Eucalyptus rostrata*	40	0·570	0·016	0·0058	0·004
8. *Eucalyptus resinifera*	42	0·664	0·014	0·0036	0·006
9. *Eucalyptus amygdalina*	43	0·689	0·013	0·0062	0·001
10. *Eucalyptus eugenioides*	45	0·898	0·014	0·0064	0·004
11. *Eucalyptus leucoxylon*	46	0·665	0·013	0·0036	0·006
12. *Eucalyptus longifolia*	47	0·836	0·010	0·0041	0·002
13. *Eucalyptus tereticornis*	48	0·613	0·013	0·0055	0·002
14. *Eucalyptus melliodora*	48	0·689	0·013	0·0055	0·002
15. *Eucalyptus sieberianus*	48	0·841	0·017	0·0048	0·008
16. *Eucalyptus cladocalyx*	49	0·713	0·014	0·0047	0·004
17. *Eucalyptus paniculata*	50	0·993	0·015	0·0060	0·003
18. *Eucalyptus hemiphloia*	51	0·576	0·013	0·0056	0·002
19. *Eucalyptus robusta*	52	0·867	0·018	0·0051	0·008
Average	43	0·776	0·014	0·0049	0·004

The figures given in Tables III and IV indicate in a general way that woods which have either relatively long cells or relatively wide cells dry out completely in a shorter time than those with relatively short or relatively narrow cells

Cussonia spicata, which dries out in thirty-five hours, has by far the widest cell elements (0.039 mm. internal diameter, as compared with 0.017 mm. in the next widest types, and an average of 0.014 mm.).

Ptaeroxylon utile, on the other hand, which takes longest to dry out (fifty-nine hours), has elements of only 0.007 mm. wide in internal diameter.

Podocarpus henkelii, which dries out in the shortest time next to *Cussonia* (thirty-seven hours), has the longest cell elements, 1.902 mm., as compared with 0.670 mm. in the case of *Ptaeroxylon*. In some of the intermediate examples the elements may be rather short but wide, or rather long but narrow.

Among the eucalypts the species *E. petiolaris* has the widest cells and dries out in the shortest time.

Comparing the eucalypts with the indigenous South African species, the averages given in the two tables are interesting. The eucalypts have shorter and much narrower elements than the indigenous species.

It is interesting to note that the various measurements given in Table III for *Ptaeroxylon utile*, the most xerophytic of the indigenous species, though differing widely from the averages of the indigenous species, are very near to the averages of the eucalypts.

General Summary and Conclusions.

1. The various conclusions reached as a result of the experiments described in this paper must all be regarded as of a somewhat tentative nature.

It must be remembered that freshly cut specimens of mature trees are not easily obtained, and it was only found possible to deal with single specimens of the thirty-one species examined. It is a matter of common experience in the seasoning of timber that individual trees of the same species vary considerably in their water-content at the time of cutting and in their rate of drying out. They vary particularly according to the situation in which the tree is growing. Species like *Ptaeroxylon utile* have a very wide range of habitats, and specimens obtained from dry river valleys would probably show a still greater degree of xerophytism than the specimen dealt with in this research which came from the same mesophytic forest as the others.

Trees also vary according to their age. Young wood loses water more rapidly and has a higher water-content than the old wood. Since the blocks used in the experiment were of the older wood, their loss of weight in each case is probably lower than would be recorded for the timber of the tree as a whole.

It is hoped in future to extend the research considerably and to investigate the range of variation in individual species, as well as further correlations between microscopic structure and rate of drying out.

2. Preliminary results indicate that—

(*a*) woods with a high water-content, which lose most weight during the process of seasoning, dry out more quickly than woods with a low initial water-content;

(*b*) hard woods take longer to dry out completely than soft woods;

(*c*) heavy, dense woods of high specific gravity take longer to dry out completely than lighter woods;

(*d*) the above correlations, however, are not very exact;

(*e*) the vessels of the wood lose their water quickly and influence the initial rates of drying out, but the further loss of water is influenced rather by the finer cell elements of the wood (tracheids and wood fibres);

(*f*) woods whose finer cell elements are relatively long or wide lose water more quickly than those whose cells are relatively short or narrow. Due value has to be given to each of these features as, in some cases, cell elements may be rather short but wide, or rather long but narrow.

3. The exotic species of eucalyptus (of which nineteen were examined) are generally considered to be more xerophytic than the indigenous species which were dealt with. The following comparisons are therefore of interest:—

(*a*) The eucalypts lose water at a more uniform rate than the indigenous species.

(*b*) The initial rate of water loss is slower in the case of the eucalypts.

(*c*) The average total times taken to dry out are very nearly the same for the indigenous species and the eucalypts.

(*d*) The eucalypts have, on an average, shorter and much narrower xylem elements than the indigenous species, but the more xerophytic species of the latter, e.g. *Ptaeroxylon utile*, are more like eucalypts.

4. These comparisons as well as the correlations between water-holding capacity and structural modifications, if fully established, are important as indicating certain means by which a clearer insight can be obtained into the meaning of xerophytism.

SECTION III.

The Water Requirement and Transpiration of a Common Natal Weed [*Bidens pilosa* (L.).]

Introduction.

Within recent years considerable prominence has been given to the suggestion made by Clements that standard indicator plants, or "phytometers," as he terms them, should be used for the experimental study of the nature of plant habitats. Such plants are, first of all, studied under carefully controlled conditions, and data are collected as to their physiological requirements and their mode and rate of growth. Similar plants may then be grown in selected plant habitats and compared with the standard plants grown under controlled conditions. The idea is an attractive one, and, according to Clements (1924) the method seems destined to undergo extensive development in the next few years. Its successful application over large areas appears to depend principally upon the choice of plants which show a wide range of adaptation, and which can easily be grown under standard conditions. As general standards, Clements considers

that such weedy herbs as *Helianthus annuus*, *Melilotus alba*, and *Brassica nigra* are most useful. Indeed, many common weeds which are often widely distributed would appear to be particularly suitable for use as standard indicators.

In the present paper some of the data, obtained with regard to the water requirement and transpiration of a very common Natal weed, are described, and these suggest that this plant might very well be used as a standard indicator for field studies in this country. *Bidens pilosa*, the blackjack, as it is commonly called, was selected for these studies because it is easily obtained throughout the year. It is one of the commonest composite weeds in Natal, and is very abundant from the Drakensberg down to the coast. It grows very rapidly, the whole life-cycle from germination to the production of seed occupying only two or three months. In the experiments to be described, attention was directed almost entirely to the water-relations of the plant, particularly its water requirement, but observations were also made upon its habit and leaf form.

I.—The Water Requirements of Plants.

The "water requirement" of a plant is defined as the ratio of the weight of water absorbed by a plant during its growth to the weight of dry matter produced. In other words, it is a measure of the amount of water used by the plant per unit weight of dry matter produced, and it therefore provides a measure of the plant's efficiency in the use of water. Its measurement may therefore prove of some economic importance in connexion with the agriculture of semi-arid regions, since the crop or variety which is most economical in its use of water is likely to be the one best adapted to regions having a limited water supply.

The earliest determinations of the water requirement of plants appear to have been made by Woodward in 1699, and since then extensive investigations on the effect of various factors, such as soil conditions, temperature, light, humidity, and so on, upon the water requirement have been carried out. The results of these investigations have been summarized and reviewed by Briggs and Shantz, and some of their more important conclusions may be enumerated here:—

1. The effect of soil moisture-content on the water requirement is to increase the water requirement when the water-content of the soil approaches either extreme.

2. The use of fertilizers causes a reduction in the water requirement.

3. The type of soil used may affect the water requirement in so far as it determines the amount of plant-food available to the crop.

4. The water requirement is influenced by limiting the amount of soil available to the roots of the plants, the water requirement decreasing within limits as the amount of soil is increased.

5. The water requirement is greater in dry than in moist air, and it increases when the carbon dioxide-content of the air is diminished.

These conclusions, amongst others, suggest that the amount of available raw food material is the all-important factor in determining the water requirement.

Briggs and Shantz themselves made an intensive study of the water requirements of crop plants growing in the Great Plains in North America. For this work, which was conducted on a very large scale, and extended over two years (1910–11), they used substantial

cans of heavily galvanized corrugated-iron (16 inches in diameter and 26 inches high), having a capacity of about 250 lb. of soil. These cans were fitted with galvanized-iron covers, through which holes were punched, suitable in size and number to accommodate the crop it was desired to grow. The space between the cover and the stem of the plant was sealed with wax to prevent the loss of water from the soil except through the plant by transpiration. To each can definite amounts of water were added periodically. Adequate aeration was secured by the changes in the air-volume of the soil accompanying the changes in the soil moisture-content. The experiments were conducted in a screened enclosure to protect the plants from hailstorms and also from birds, and the plants were harvested at the stage when similar crops were harvested in the field. The green weight of the cropping from each can was taken and the cropping placed in a steam-oven and dried, and the dry weight taken. Knowing the initial and final weight of the cans and also the total amount of water added to each, the amount of water used by each crop was easily estimated.

A series of similar experiments was conducted in India between 1908 and 1910 by Leather. The plants were grown in glazed stone-ware jars, no wax-covering being used to prevent loss of water from the surface of the soil. The error due to water loss from the jars, other than through transpiration from the plants, was to some extent eliminated by using control jars in which no plants were grown. These experiments conclusively demonstrated the effect of different sized jars on the water requirement, the general conclusion being that the larger the jar or, in other words, the greater the soil-mass the lower is the ratio.

A.—The Determination of the Water Requirement of the Blackjack in Pot Cultures.

For the present investigation it was decided to follow as nearly as possible the method outlined by Briggs and Shantz of growing the plants in sealed containers rather than in open pots. So long as the surface of the soil is exposed to the air a considerable error must be introduced owing to the evaporation of water from the soil in addition to its loss through transpiration by the plant. Nor can this error be fully eliminated even by the use of control pots, for the evaporation from a bare soil surface is scarcely likely to be comparable to that from a surface in which plants are growing. Objection has been taken to the use of closed tins on the ground that the aeration of the soil in them would be poor, and that this would have a detrimental effect upon the normal development of the plants. Briggs and Shantz found, however, that the growth of plants in such containers was luxuriant and healthy. There was no massing together of the roots, which extended to every part of the soil-mass, and there was no odour other than that of well-aerated soil. They conclude that good aeration of the soil is obtained through the changes in the air-volume of the soil accompanying the changes in soil moisture-content.

The size of the tins to be used was a question of some difficulty. Briggs and Shantz used large galvanized-iron cans of 250 lb. soil capacity, but the average botanical laboratory does not possess the necessary apparatus for weighing such large containers. Preliminary experiments were made with ordinary cylindrical coffee tins, about $3\frac{1}{2}$ inches in diameter and $6\frac{1}{2}$ inches in height, with a capacity of about 3 lb. (1,300 gramme) of soil, and as the plants made healthy,

vigorous growth in these it was decided to use them, since they could easily be weighed on an ordinary large balance registering up to 2 kilograms.

Undoubtedly it would have been better to have used larger tins, for the greater the soil-mass the closer one gets to natural conditions. As has already been mentioned, investigations in India (5) have shown that the larger the container used (that is, the larger the soil-mass) the lower will be the water requirement ratio. However, seeing that all the tins used were the same size, the main purpose of the investigation, namely, the effect on the water requirement of varying one particular factor, was not likely to be affected by the comparatively small size of the containers.

These tins were provided with tightly fitting lids, through which three holes were punched, each hole being made of sufficient size to allow of the growth of one plant. A fourth hole was made in the middle of the lid and a glass tube was inserted through this into the soil-mass. This tube was to allow for the addition of water. The space between the lid and the tube was filled in with wax, as was the junction between the lid and the container.

Previous investigators have shown that the type and texture of the soil used have an indirect effect upon the water requirement, so that care has to be taken to secure soil of a uniform texture. Ordinary garden soil of normal water-content (27 per cent.) was chosen and a large quantity of it placed in a box and thoroughly mixed, all lumps and hard clayey masses being carefully sifted out. The tins were then filled, the soil in each box being well compacted, as loosely packed soil would subsequently set and, in doing so, would tend to break the wax seals round the plants. Before closing the tin some of the soil was removed and a handful of gravel substituted. A glass tube, 6 inches long, was then passed through the hole in the centre of the lid in such a way that, on closing the tin, its end would be surrounded by gravel. The presence of the gravel facilitates the watering, as it provides an additional surface for the absorption of water. Soil was then added to the tin so as to bring the soil surface just above the level of the top of the tin, and the lid was then fitted on.

The seeds were not planted directly in the tins, but were first sown in seed-boxes and allowed to germinate. When the seedlings were two days old they were transplanted to the tins, care being taken not to injure them in any way. A small hole was made with a knife in the soil beneath each of the holes in the lid. A seedling was then placed with its roots in this hole and the soil carefully replaced round it. The exposed surface of the soil between the stem of the seedling and the cut edge of the lid was then covered with a thin coat of wax. The wax used was of low melting point and consisted of eight parts of beeswax and two of tallow, as recommended by Briggs and Shantz. The wax was just melted and then quickly applied with a small brush, care being taken not to scorch the delicate stems of the seedlings. The wax-seal was gradually thickened as the plants grew older and stronger.

Water was added to the tins from a measuring flask. A small thistle-funnel was attached by rubber-tubing to the top of the protruding glass tube so that water could easily be poured into the tin. When the funnel was not in use the rubber-tubing was closed with a pinch-cock. Each tin was weighed before watering, and as definite amounts of water were added one had an idea approximately of the water-content of the soil in each tin.

The tins were weighed first immediately after the application of the wax-seals and then at regular weekly intervals. As the plants reached maturity the tins were weighed every three days. The final weighing was taken just before the removal of the plants.

As soon as the plants began flowering, the tins were opened, the lid being cut away round each plant. The tins were then opened along one side and the plants carefully removed with their roots attached. The soil adhering to the roots was removed and the fresh weight of the three plants from the tin was immediately ascertained. The plants were then dried in a steam-oven and their dry weight determined.

In order to calculate the water requirement it is necessary to know (1) the total amount of water added to the tin, (2) how much water has been lost through transpiration, (3) the difference in the water-content of the soil at the beginning and the end of the experiment, and (4) the dry weight of the plants. The amount of water actually used by the plants will, of course, be equal to the total amount of water added to the tins plus or minus the difference in the water-content of the soil at the beginning and the end of the experiment. The final weight of the full tin, less the fresh weight of the plants, gives the actual weight of the tin plus the soil at the end of the experiment. The difference between this and the initial weight of the full tin gives the difference in the water-content of the soil at the beginning and the end of the experiment. Knowing this and the total amount of water added to the tin, the amount of water actually used by the plants is easily calculated. The water requirement is the ratio of this amount to the dry weight of the plants.

B.—Experimental Results: The Effect upon the Water Requirement of Varying the Amount of Water Supplied.

The first experiment aimed at determining the effect upon the water requirement of varying conditions of soil moisture-content. Twenty-five tins were taken and three plants grown in each. The tins were divided into five groups, with five tins in each, and all the tins were kept in the same greenhouse under uniform conditions of temperature, light-intensity, humidity, and so on. Definite amounts of water were added to the tins periodically, these amounts being in the proportion of 5 : 4 : 3 : 2 : 1 for the different groups. Thus at the beginning of the experiment each tin of Group 1 received 25 c.c. of water at weekly or fortnightly intervals, according to the water-content of the soil; the tins of Group 2 received 20 c.c. each; those of Group 3, 15 c.c. each; those of Group 4, 10 c.c each; and those of Group 5, 5 c.c. each at the same intervals. Later, as the plants reached maturity, these amounts were increased, but the same proportion was maintained between them.

The effect on the external appearance of the plants of thus varying the soil moisture-content was very marked, as may be seen from the accompanying photographs (Plates I and II). The plants in the first group of tins, to which the largest amounts of water were added, were quite normal in appearance and their growth was vigorous, while those in the fifth group, to which the smallest amounts of water were added were small and stunted, the leaves being very reduced in size and many of them very much divided. In every case there was a striking series of leaf forms passing from a very divided type through a simple dentate type to a compound type. This variation in leaf form

will be more fully dealt with later. The plants of the second, third, and fourth groups were intermediate in size between those of the first and fifth groups (Plate II, Fig. 4).

The total amount of water added to each tin was:—Group 1, 500 c.c.; Group 2, 400 c.c.; Group 3, 300 c.c.; Group 4, 200 c.c; Group 5, 100 c.c. The amount of water transpired by the plants in each tin appeared to be roughly proportional to the amount of water added. In practically every instance it was found that the loss of water was always greatest in tins of the group which received most water. This may be seen on examination of the table showing the amounts of water lost periodically from the tins during the experiment.

TABLE I.

Showing the Effect of Varying the Soil Moisture-content upon the Water Requirement of Bidens pilosa. *19th May to 19th September*, 1923.

Series.	Tin.	Total Amount of Water Added.	Total Amount of Water Used by Plants.	Dry Matter.	Water Requirement.
		c.c.	c.c.	gms.	
1.....	A	500	463·76	0·7947	583·5
	B	500	401·42	0·6371	629·9
	C	500	—	—	—
	D	500	464·03	1·0294	464·3
	E	500	375·19	0·5913	634·5
		c.c.	c.c.	gms.	
2.....	A	400	330·95	0·4589	721·1
	B	400	368·49	0·5543	664·8
	C	400	379·02	0·7006	540·9
	D	400	371·66	0·6013	618·1
	E	400	376·14	0·6231	603·6
		c.c.	c.c.	gms.	
3.....	A	300	208·14	0·2851	—
	B	300	294·97	0·6375	462·8
	C	300	297·75	0·5482	543·3
	D	300	296·76	0·4971	597·0
	E	300	291·46	0·5332	546·7
		c.c.	c.c.	gms.	
4.....	A	200	227·19	0·4424	513·6
	B	200	210·01	0·4125	509·3
	C	200	204·0	0·4240	481·0
	D	200	197·43	0·3501	563·9
	E	200	204·37	0·4023	508·1
		c.c.	c.c.	gms.	
5.....	A	100	109·02	0·1793	607·8
	B	100	108·67	0·2063	526·4
	C	100	120·83	0·1525	792·1
	D	100	83·35	0·1245	669·5
	E	100	96·0	0·1799	533·5

The above results give the following as the mean water requirement for the plants of each group.

Group 1, 578.1. Group 2, 629.2. Group 3, 537.4.
Group 4, 515.2. Group 5, 625.9.

Each water requirement determination was based on measurements carried out simultaneously in the five tins of each series. The water requirement of the plants in each tin was determined separately and the mean of the five determinations was taken to represent the water requirement of the plants of that particular group. The results are shown in Table I.

Examination of these results shows no definite correlation between the water requirement ratio and the amount of water added. For

instance, the plants of Group 2 have as high a water requirement as those of Group 5. This is in accordance with the general conclusion drawn by Briggs and Shantz that the water requirement increases as the water-content of the soil approaches either extreme.

An interesting fact may be mentioned in connexion with the results from Group 1. The growth of the plants in the tin D was far more vigorous than that of plants in other tins of this group. (See Plate I, Fig. 1, central tin.) The results in Table I show that the water requirement ratio for this tin was exceptionally low. This accords with Leather's view that whatever aids in the good development of a crop tends towards an economy of water.

C.—Experimental Results: The Effect of Wind upon the Water Requirement.

Method.—As before, twenty-five tins with three plants in each were taken and divided into five groups with five tins in each group. An electric-fan was used to produce an air-current. Each group of tins was placed at a definite distance from the fan, except one, which was kept as a control and was exposed to the ordinary conditions of the greenhouse. The first group of tins was placed at a distance of $2\frac{1}{2}$ feet from the fan, the second at $7\frac{1}{2}$ feet, the third at $12\frac{1}{2}$ feet, and the fourth at $17\frac{1}{2}$ feet. Plate III shows the general arrangement. The greater the distance from the fan the less will be the velocity of the air-current, and consequently the different groups of plants will be exposed to currents of different intensities. The control group was sheltered from the current produced by the fan by means of a suitable screen. As far as was possible all the other conditions likely to affect the water requirement were made the same and equal amounts of water were added to each tin.

In the centre of each group of tins a porous cup atmometer was set up and the amount of water evaporated from each of these was measured for a definite period.

From these readings it was possible to gain a fairly accurate idea of the relative evaporating power of the air at the five points where the tins were placed. The evaporating power of the air is, of course, dependent, not only on the velocity of the air-current, but also on such factors as temperature and relative humidity. In the present experiment, however, all the atmometers are exposed to practically identical conditions as regards temperature and humidity, and the relative evaporating power therefore affords an approximate measure of the velocity of the air-current. A number of readings were taken at different periods during the growth of the plants, and then the total amount of water evaporated during the different periods was found. The results are given in Table II.

Table II.

Loss of Water by Evaporation from Atmometers in Moving Air.

Length of Period for which Atmometers were Read.	Atmometer Number.	Distance from Fan.	Amount of Water Evaporated.	Ratio.
		Feet.		
Ninety-two hours.....	1	$2\frac{1}{2}$	155·14	3·4
	2	$7\frac{1}{2}$	332·33	2·5
	3	$12\frac{1}{2}$	237·25	1·75
	4	$17\frac{1}{2}$	207·72	1·5
	5	Control	135·06	1·0

It will thus be seen that the air passing over the plants nearest the fan had an evaporating power nearly three and a half times as great as that of the air surrounding the control plants. At a distance of 17½ feet from the fan, however, the evaporating power of the air was very little greater than in the case of the sheltered plants.

TABLE III.

Showing Results of Experiments on the Effect of Wind upon the Water Requirement.

Period of growth, 20th June to 27th November, 1923.
Total amount of water added to each tin, 575 c.c.

Group No.	Tin No.	Distance from Fan.	Atmometer Ratio.	Total Amount of Water used by Plants.	Dry Matter.	Water Requirement.
5	1	Control	1·0	562·1	0·9084	619
	14			564·4	0·9312	606
	16			565·9	0·9458	598
	24			557·6	0·8892	627
	25			560·4	0·9312	602
1	2	2½ ft.	3·4	484·4	0·5114	947
	11			555·1	0·6332	877
	8			554·4	0·5538	1001
	4			550·0	0·4880	1127
	22			558·3	0·5850	954
2	7	7½ ft.	2·5	568·5	0·9186	619
	19			571·2	0·8786	650
	3			576·1	0·8588	670
	21			561·9	0·8642	650
	23			576·3	0·9602	600
3	10	12½ ft.	1·75	570·1	0·9760	584
	6			569·6	0·8497	670
	13			568·8	0·8346	681
	17			560·2	0·8164	686
	5			567·3	0·7992	710
4	9	17½ ft.	1·5	574·5	0·8482	676
	20			567·5	0·8448	670
	18			563·5	0·8330	677
	12			560·0	0·7952	704
	15			571·8	0·8414	679

From the above results the mean water requirement for each group is:—

Group 5, 610; Group 1, 981; Group 2, 638; Group 3, 666; Group 4, 681.

The Effect upon the Growth of the Plants.—The plants in this experiment were much slower in growing than those of the previous experiment. Those that were sheltered from the strong air-current produced by the fan grew more or less normally, as did those of the second, third, and fourth groups. Plate IV, Fig. 1, shows the plants of the fourth group just before flowering, and Diagram V shows a typical series of leaf forms of the plants of these four groups. The effect of the wind on the plants of Group 1, situated at a distance of 2½ feet from the fan, was very marked, as may be seen from Plate IV, Fig. 2. A diagrammatic representation of one of these plants is shown in Diagram VI. The leaves of these plants exhibited very clear symptoms of distress. First, there was a shrinkage of the

margins and the gradual development of brown spots, resulting in extreme cases in the total drying out and death of the leaves. The leaves were not flat as is normally the case, but the margins curled under and the central portions bulged outwards, and the tissues at the margins frequently dried up and died. Indeed, the whole appearance of the leaves was evidence of the very adverse conditions under which the plants were growing.

Results.—An examination of the results which are tabulated in Table III shows that there was a very marked difference between the water requirement ratio of the control plants and that of the plants nearest to the fan. In the case of the remaining groups, situated at various distances from the fan, the water requirement was higher than for the control group, though there is not any marked difference. Nor do the ratios for these groups differ very appreciably from one another. It would seem, therefore, that while wind of a relatively low intensity is without any marked effect on the water requirement ratio, wind of a high intensity considerably increases the ratio.

It is interesting to notice that the actual amount of water used by the plants is very nearly the same for all five groups. In fact, the plants of Group 1 used, if anything, less water than those of the control group, although they were exposed to conditions favouring a much greater loss of water. This, of course, was probably due to the poor development of these plants and their smaller leaf-surface.

These results appear to afford further confirmation of Leather's conclusion that the more perfect the development of the plants the lower is the water requirement. The plants of the first group were very poorly developed as a whole, and many of their leaves withered and died. The ratio for this group was exceptionally high, whereas for the other groups where the growth was very nearly normal it was considerably lower.

D.—Water-content and Transpiration Experiments.

The rates of water loss of the blackjack were measured at various stages of development of the seedlings and of the mature plant by the method of observing the rates of drying out as well as by measuring periodically the water lost from the tins in the above experiments.

For the purpose of the experiments a large number of blackjack seeds were sown in a number of shallow seed-boxes. Germination was very rapid, taking from two to three days in an unheated greenhouse. The first experiment was carried out after the seedlings had been growing for two weeks.

Twenty representative seedlings were selected in each of three sets which were run simultaneously and the results averaged. The seedlings were clipped off near the soil and weighed. They were then spread out on a piece of white paper and weighed at half-hour intervals. This drying out was allowed to continue for four hours, after which the seedlings were placed in a steam-oven, dried out completely, and the dry weight determined. The total initial water-content is taken as 100, and the loss at the end of each half-hour interval shown as a percentage of this. Similar sets of experiments were performed for seedlings of three weeks old up to those of nine weeks old, as well as for mature plants, both at the flowering and seeding stage. The night before each experiment was carried out the plants or seedlings were well watered to ensure their being as turgid as possible on the morning of the following day when the experiments were commenced.

Table IV.

Showing the Percentage Decrease of Initial Water-content at Half-hour Intervals during the Drying Out of Seedlings and Mature Plants.

No. of experiment	1	2	3	4	5	6	7	8	9	10
Age of plants	1–2 weeks	3 weeks	4 weeks	5 weeks	6 weeks	7 weeks	8 weeks	9 weeks	Plants Flowering.	Plants Seeding.
Fresh water in grammes	0·2931	0·4100	0·5880	0·6035	0·6848	0·9295	0·9262	1·0872	1·2555	1·3642
Dry weight in grammes	0·0154	0·0263	0·0382	0·0502	0·0712	0·0999	0·1226	0·1399	0·2102	0·1512
Initial water in grammes	0·2777	0·3837	0·5498	0·5533	0·6136	0·8296	0·8036	0·9473	1·0453	1·2130
Water after 0 hour, per cent	100	100	100	100	100	100	100	100	100	100
,, ½ hour ,,	93·39	93·41	93·61	91·60	92·39	96·66	94·10	94·65	98·02	96·32
,, 1 hour ,,	90·77	91·36	91·16	88·28	86·95	95·35	91·16	91·62	96·52	93·79
,, 1½ hour ,,	89·15	89·47	89·47	85·81	84·10	93·48	89·13	89·04	95·14	92·20
,, 2 hours ,,	86·72	87·49	88·11	84·79	81·88	92·20	87·13	87·77	93·95	91·02
,, 2½ hours ,,	85·73	86·06	86·97	82·95	80·23	89·92	85·20	86·19	92·79	90·04
,, 3 hours ,,	83·14	84·00	85·47	81·23	78·12	88·16	83·33	84·28	91·78	89·33
,, 3½ hours ,,	81·15	82·18	84·60	78·98	76·75	86·41	81·14	82·57	90·99	88·57
,, 4 hours ,,	79·28	80·40	83·37	78·16	75·48	85·0	78·99	80·79	89·94	87·56

The rates of water loss for the seedlings of different ages are remarkably uniform when expressed as percentages of the total initial water-content. Any slight differences may have been due to slight variations in the temperature and relative humidity of the greenhouse which it was impossible adequately to control. The mature flowering plants are, however, as was to be expected, shown to be somewhat more resistant to water loss, retaining a slightly higher percentage of their water-content at the end of the first four hours of drying out. If the initial rates of drying out, say, for the first half-hour, are taken to be more or less equal to, or at least proportional to, the rates of transpiration, then the actual amounts of water transpired are shown to be more or less proportional to the weight and therefore to the age of the seedlings. At the flowering stage there is a drop in the rate of transpiration, but it again increases slightly in the older seeding plants.

Observations of the rates of transpiration were also made by determining the amounts of water lost periodically from the series of twenty-five tins used in the first experiment (see Table I). The results are tabulated in Table V. Each calculation represents the average loss of water from five tins for a definite period. The amounts of water added to each of the series 1, 2, 3 4, and 5 were, it may be recalled, in the proportions of 5, 4, 3, 2, and 1.

While, as already shown, there was no definite correlation between the " water requirement " ratio and the amount of water added, or, in other words, with extra water, the plants grew more rapidly, and there was a corresponding increase of dry material, yet the results in Table V show clearly that the total water lost was always greater in the plants that received most water. The observations on the rates of drying out, however, given in Table IV would indicate that this greater total loss of water is to be explained simply by the increased development and size of the plants.

However, it was further shown by the results given in Table IV that while the seedlings up to nine weeks old lost water in proportion to their size and water-content, the mature plants, on the other hand, did show a smaller rate of water loss. In the series of plants in tins careful observations went to show that the total amounts of water lost—while, of course, increasing the size of the plants—also could be correlated with variations in the form of the leaves. These are illustrated in the Diagrams I–VI.

In all five series, irrespective of the amounts of water added, at first there was a slow increase in the amounts of water transpired corresponding to a slow increase in the size of the plants. This stage was maintained for the first eleven weeks. During this period the plants had leaves of a divided type (Diagram I—A, B, and C). It was noticed, however, that the amount of leaf division was reduced somewhat in the first two series which had most water added and lost most.

As the first-formed leaves filled out and new ones were produced transpiration increased. After the twelfth week (10th to 17th August in Table V) there was a rapid rise in the amount of water transpired from each tin, particularly those in the first second, and third series (those getting most water). Here it was noticed that leaves of the undivided type (Diagram I—D and F) had been produced.

Table V.

Series.	Average Daily Amounts of Water (in c.c.) lost from the Plants in each Series periodically.													
	To 29th May. 7 days.	To 12th June. 14 days.	To 2nd July. 20 days.	To 8th July. 6 days.	To 16th July. 8 days.	To 24th July. 8 days.	To 3rd Aug. 10 days.	To 10th Aug. 7 days.	To 17th Aug. 7 days.	To 24th Aug. 7 days.	To 31st Aug. 7 days.	To 7th Sept. 7 days.	To 14th Sept. 7 days.	To 19th Sept. 5 days.
1	Practically no water lost in this period.	0·19	0·40	0·40	0·50	0·69	0·92	1·11	3·59	6·60	7·21	12·76	15·80	11·00
2		0·17	0·40	0·40	0·53	0·74	0·99	1·16	3·21	5·07	6·69	11·06	12·63	8·40
3		0·13	0·31	0·33	0·41	0·61	0·82	1·00	2·89	4·26	5·14	8·11	9·71	6·96
4		0·12	0·25	0·30	0·36	0·53	0·63	0·79	1·91	2·71	4·13	5·83	6·72	5·20
5		0·12	0·22	0·23	0·35	0·53	0·46	0·50	1·10	1·34	1·60	2·33	3·14	2·60

During the last week a rather striking falling off in the ratio of water loss was shown. Too great stress perhaps should not be laid on this fact, since the plants of all the groups behaved in the same way, and it may have been due to some unnoticed change in the environmental conditions which were kept throughout as uniform as possible. Nevertheless, it was rather noteworthy that the latest formed leaves were again of a divided type (Diagram I—G and H).

In every case where a plant flowered the flower was produced after six pairs of leaves (excluding the cotyledons) had been formed, and the sixth pair of leaves were always very much divided. The drying out experiments showed that, at the flowering stage, the resistance to water loss increased. This, combined with the fact that the production of the undivided type of leaf was in every case combined with increased transpiration, may have some significance.

While the evidence can hardly be considered conclusive, it may be the case that leaf division is to be considered a means of helping to curtail water loss. It is certainly the case that, at least among the trees and shrubs of South Africa, species with divided leaves are much more common in open xerophytic types of plant community than in close forest (Bews, 1925).

If a definite and easily recognizable morphological feature, such as degree of leaf division, could be shown to be correlated with the degree of moisture in the habitat, then the usefulness of such a plant as *Bidens pilosa* as a plant indicator would be largely increased.

Summary and Conclusions.

In the present investigation of the water requirement and transpiration of *Bidens pilosa* it has been shown that—

(1) differences in soil moisture-content affect the growth and vigour of the plant, but do not have any great effect on the water requirement, i.e. the ratio of dry material formed to water used. Thus plants which received 400 c.c. of water produced almost exactly four times the dry weight in the same time as plants which received only 100 c.c. The water requirement was lowest in the plants which received 200 c.c. of water (series of five tins);

(2) in one of the series of tins which received 500 c.c. of water the growth of the plants was most vigorous of all, and these plants showed the lowest requirement of all, indicating that vigorous growth tends towards an economy of water;

(3) the effect of wind is to increase the water requirements, though not proportionally to the velocity of the wind or to the increased evaporating power of the air. The evaporating power of the air can be increased up to two and a half times with only a slight increase in the water requirements of plants. Beyond that, a very marked increase in water requirement is shown;

(4) experiments on water-content and rates of drying out showed that seedling plants up to nine weeks old dried out at a very uniform rate, i.e. they lost more or less equal percentages of their water-content in equal times. The actual amounts of water lost, therefore, are more or less proportional to the weights of the plant or to their total water-content. Plants at the flowering stage are more resistant to water loss, though the rate of loss again increases slightly at the seeding stage;

(5) measurements of transpiration by the plants growing in the tins used for determining the water requirements showed that in every case most water was lost by the plants which received most. While this was generally to be expected, certain variations in the rate appear to be correlated not only with the increase in size of the plants, but with variations in the form of the leaves produced.

To begin with, the leaves are simple but deeply cut, and the transpiration rates remain uniformly low, increasing slowly with the growth in size of the plant. Then leaves of a simple, dentate, undivided type are produced, and there is a sudden rise in the rate of transpiration which goes on increasing with the growth of the plant. Just prior to flowering, a pair of divided compound leaves are produced, and instead of the transpiration rate continuing to increase with the increased size of the plant, there appears to be a definite diminution of the rate. The plants which received least water not only grew more slowly in proportion, but had more markedly divided leaves.

This evidence is not considered sufficiently conclusive to show that there is any causal inter-relationship between the form of the leaves and the rates of water loss, but in any case the facts are worth recording. It would add considerably to its value as an indicator plant if the blackjack could be shown to exhibit such striking morphological responses to variations in the environmental conditions.

(6) Apart from this, *Bidens pilosa* is entirely suitable for use as an indicator plant or phytometer. Its seeds can be easily obtained, they germinate quickly and easily, and the plants can be readily established. Healthy plants can be brought to maturity and form seed in a few months when planted in relatively small sealed containers that can be transported and weighed without undue trouble. Examination of the tins afterwards showed that the roots were excessively ramified, penetrating to every portion of the tin. This suggests very efficient water absorption.

Stages of wilting are easily observed in the blackjack, and the response of a wilted plant to the addition of small quantities of water is very marked, the normal condition of turgidity can be restored in a few minutes. This sensitive character is very useful where the blackjack is used for determining wilting coefficients in soils.

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Bidens pilosa. VARIATION IN LEAF-FORM.

A B, First leaves, very divided, water loss low. C, Transitional type. D, D (1), Undivided leaves, water loss higher. F. Mature leaf. E, Transitional type. G. H, Compound leaves.

DIAGRAM II.

Typical plant of Group V, the tins of which received the smallest amount of water The leaves are small and all are divided. Mean water requirement 625·9.

DIAGRAM III.

Typical plant of Group I, the tins of which received five times as much water as Group V. Mean water requirement 578·1.

DIAGRAM IV.

Typical plant of Group II.

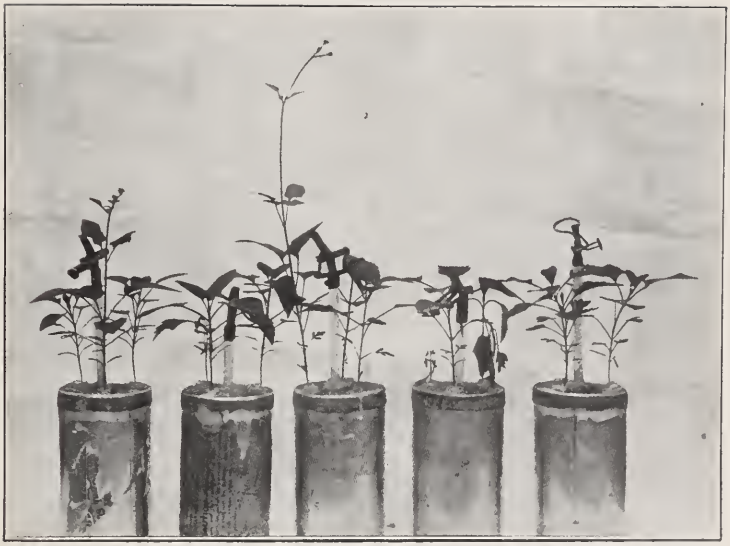
DIAGRAM V.

Series of leaves from the different groups of the experiment showing the effect of wind. The series passes from the very divided type (5 and 6) to the less divided type (3 and 4), and to the simple type (2), and finally to the compound type (1).

DIAGRAM VI.

Typical plant from the Group nearest to the fan.

PLATE I.



1A. 1B. 1D. 1C. 1E.

FIG 1.—*Bidens pilosa.*

Group 1.—(Received the largest amount of water.) Water requirement : 578·1.

FIG 2.

Group 5.—(Received the smallest amount of water.) Water requirement 625·9

PLATE II.

FIG 3.—*Bidens pilosa.*

The first two tins are from Group 1, the second two from Group 5. The plants are all of the same age. The photo shows admirably the effect of large and small amounts of water on the growth of plants.

1 2 3 4 5

FIG 4.

The above shows one specimen from each Group, showing that a decrease in growth accompanies a decrease in the amount of water.

PLATE III.

Bidens pilosa.

The above photographs show two views of the arrangement of the experiment, showing the effect of wind (from electric fan) on the water requirement.

BOTANICAL SURVEY OF SOUTH AFRICA

MEMOIR No. 9

A PRELIMINARY LIST

OF THE

KNOWN POISONOUS PLANTS FOUND

IN

SOUTH AFRICA

By E. P. Phillips, M.A., D.Sc., F.L.S., F.R.S.(S.Afr.).

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A Preliminary List of the Known Poisonous Plants found in South Africa.

By E. P. Phillips, M.A., D.Sc., F.L.S., F.R.S.(S.Afr.)

The poisonous plants of South Africa play a very important rôle in the stock-raising industry of the country, as the annual loss of the stock by plant poisoning is very considerable. Our present knowledge of plants poisonous to stock is mainly due to the researches carried out by the Division of Veterinary Education and Research, and while this knowledge is yet very incomplete, sufficient data have been collected to warrant a botanical description of such species as have been definitely proved poisonous.

The present list deals with eighteen families, forty genera, and in all with fifty-five species of plants. Only species are included which have been definitely proved, by experimental feeding tests, to be injurious to stock, or which by chemical analyses are known to contain poisonous substances. The list could have been considerably enlarged by the inclusion of plants reputed to be poisonous and by those species which gave negative results in feeding tests. The latter cannot always be definitely ruled out of court as non-poisonous, since experience has shown that plants which gave negative results in the first experiments were later proved to be responsible for well-defined stock diseases, e.g. *Tribulus terrestis*, *Vangueria pygmaea*.

It is not within the scope of this account to discuss the symptoms caused by the various species enumerated in the list, most of these will be found in the various reports issued by the Division of Veterinary Education and Research. It is hoped that the brief descriptions of the plants and the key given to the genera will enable veterinary officers to recognize in the field any of the known poisonous plants and thus be of some assistance when investigating an outbreak of stock disease where vegetable poisoning is suspected. The ability to recognize the plants in the field may in some cases be of material assistance, as farmers are apt to incriminate, in fatal cases, plants recently eaten by the animal, whereas death may be due to a plant eaten some considerable time previously, e.g. in the case of *Vangueria pygmaea* and *Matricaria nigellaefolia*.

It may not be out of place here to emphasize the importance of preserving in some public herbarium a good specimen of the plant used in any feeding tests or chemical analyses. If this simple and essential precaution is adopted, there can never be any doubt in the future as to the actual plant under investigation. In looking through records one

frequently finds the plant recorded as *Indigofera* sp., *Scilla* sp., etc.; for some reason or other (probably the material being too fragmentary) no specimens have been kept, so that the results obtained from work on such plants lose much of their value.

In the following pages all references to feeding tests, unless otherwise stated, indicate that these tests have been carried out by the Division of Veterinary Education and Research.

In conclusion, the writer is indebted to Miss K. A. Lansdell, of the Division of Botany, for the preparation of the plates.

KEY TO GENERA.

1. Grasses ..... 2.
   Herbs, shrubs, or trees, not grasses ..... 3.
2. Ligule a ciliated rim ..... (13) *Setaria.*
   Ligule membranous ..... (14) *Sorghum.*
3. Plants with underground bulbs or corms or tuberous roots; leaves all radical ..... 4.
   Trees, shrubs, herbaceous plants, or climbers; if with a large underground tuber then leaves not radical ..... 11.
4. Flowers in an umbel at the end of an evident flower-stalk ..... 5.
   Flowers in racemes, or several flowers from a common spathe ..... 7.
5. Flowers blue ..... (25) *Agapanthus.*
   Flowers red ..... 6.
6. Flowers subtended by 2 spathe-valves ..... (2) *Buphane.*
   Flowers subtended by 5–8 reddish-brown spathe-valves ..... (1) *Haemanthus.*
7. Flowers in racemes; underground rootstock a bulb ..... 8.
   Flowers developing successively from a common spathe; underground rootstock a corm ..... 10.
8. Flowers blue ..... (29) *Scilla.*
   Flowers not blue ..... 9.
9. Flowers white; flower-stalk tough; leaves appearing at the same time as the flowers .. (28) *Ornithogalum.*
   Flowers white; flower-stalk herbaceous; flowers appearing before the leaves ..... (31) *Urgenia.*
10. Style-branches petaloid, transversely stigmatose at the base of the large crests ..... (16) *Moraea.*
    Style-branches petaloid, with 2 small divergent crests, papillose round their edges ..... (15) *Homeria.*
11. Plants furnished with tendrils ..... 12.
    Plants without tendrils ..... 14.
12. Tendril at tip of leaf ..... (27) *Gloriosa.*
    Tendrils from same node on the stem as the leaf 13.
13. Leaves palmately lobed ..... (33) *Adenia.*
    Leaves heart-shaped at the base, not palmately lobed ..... (10) *Melothria.*

14. Plant of much-branched leafless stems..... (26) *Bowiea.*
Plants with well-developed leaves..... 15.
15. Leaves compound, or much dissected..... 16.
Leaves simple..... 27.
16. A semi-marsh plant; flowers in a head with white ray florets..... (6) *Matricaria.*
Non-marsh plants; flowers usually solitary, in racemes or panicles..... 17.
17. Leaves bipinnate..... (20) *Erythrophloeum.*
Leaves pinnate or 3–5-foliate..... 18.
18. Fruit breaking up into nutlets, each armed with 2 spines..... (39) *Tribulus.*
Fruit not spiny..... 19.
19. Flowers regular; stamens 5..... (37) *Hermannia.*
Flowers irregular; stamens 4 or 10..... 20.
20. Leaflets about 6 in. long, forming a wing down the common rhachis..... (32) *Melianthus.*
Leaflets varying, up to about 2 in. long, not forming a wing down the common rhachis... 21.
21. A climbing plant; seeds scarlet, with a black area at one end..... (17) *Abrus.*
Trees, shrubs, or prostrate plants; seeds not scarlet..... 22.
22. Fruit a membranous or inflated pod, sometimes spherical or sub-globose..... 23.
Fruit a flattened pod..... 25.
23. Leaves pinnate..... 24.
Leaves 3–5-foliate..... (19) *Crotalaria.*
24. Racemes of flowers longer than the leaves.... (18) *Cassia.*
Racemes of flowers shorter than the leaves.... (21) *Lessertia.*
25. Largest petal glabrous or sparsely hairy without; keel twisted..... (23) *Phaseolus.*
Largest petal very hairy without; keel not twisted..... 24.
26. Flowers in racemes shorter than the leaves.... (22) *Mundulea.*
Flowers on a long peduncle exceeding the leaves, or in a large terminal raceme..... (24) *Tephrosia.*
27. Leaves opposite or whorled..... 28.
Leaves alternate or tufted..... 33.
28. Flowers grouped in heads; fruit crowned with bristles..... (7) *Pteronia.*
Flowers not grouped in heads; fruit not crowned with bristles..... 29.
29. Leaves opposite..... 30.
Leaves in whorls of 3–4..... 32.
30. Leaves fleshy; flowers large, reddish..... (9) *Cotyledon.*
Leaves not fleshy; flowers greenish-yellow or pinkish-white..... 31.
31. A large shrub or small tree; flowers pinkish-white..... (3) *Acokanthera.*
An acaulescent plant; flowers greenish-yellow (35) *Vanqueria*

32. Flowers showy, red or white ; leaves in whorls of 3..... (3) *Nerium.*
Flowers inconspicuous ; leaves in whorls of 4. (12) *Toxicodendron.*
33. Stems succulent, tubercled with the persistent bases of the leaves..... (9) *Cotyledon.*
Stems not succulent and tubercled..... 34.
34. Flowers in heads surrounded by a series of involucral-bracts..... 35.
Flowers various, if massed in a head then not surrounded by a definite involucre and bark tough..... 37.
35. Fruits crowned with a tuft of soft white bristles (8) *Senecio.*
Fruits crowned with scales or naked..... 36.
36. Fruits naked..... (4) *Dimorphotheca.*
Fruits crowned with scales..... (5) *Geigeria.*
37. Flowers large, trumpet-shaped ; fruits spiny... (35) *Datura.*
Flowers not large and conspicuous ; fruits not spiny..... 38.
38. Leaves small, lanceolate, closely covering the stem..... (38) *Gnidia.*
Leaves not crowded and overlapping on the stem..... 39.
39. A stemless woody plant with underground rootstock..... (11) *Dichapetalum.*
Small shrubs or herbs..... 40.
40. A small shrub..... (37) *Hermannia.*
Annual herbs..... 41.
41. A prostrate plant covered with star-shaped hairs (31) *Malva.*
An erect glabrous plant..... (36) *Solanum.*

AMARYLLIDACEAE.

Usually acaulescent herbs ; rootstock a bulb or corm. *Leaves* radical. *Inflorescence* an umbel or raceme, rarely a head, or flowers solitary. *Spathe-valves* usually 2, sometimes numerous and coloured. *Flowers* bisexual, regular or nearly so. *Perianth* petaloid ; segments 6. *Stamens* usually 6 ; filaments free or sometimes united at the base. *Ovary* inferior, more rarely half-inferior, 3-chambered, with 1 to many ovules in each chamber ; style simple ; stigma capitate or tricuspidate, rarely with 3 distinct branches. *Fruit* usually a 3-valved capsule, more rarely a berry.

Genera about 70, with almost 700 species, widely spread in the temperate and tropical regions of both hemispheres ; 26 genera and with almost 300 species are recorded from South Africa.

The family contains many species of known or reputed poisonous properties, and as a general rule a member of the family should be regarded as one of the suspected plants in cases of plant poisoning.

1. Haemanthus natalensis, Pappe.

Bulb globose, 5–8 cm. in diameter ; scale leaves about 4, tipped and spotted with red. *Leafy stem* 0.3–0.6 m. high, spotted with red brown marks. *Leaves* 8 or more, 0.3–0.6 m. long, oblong, narrowed at the base, bright green, some spotted on the back. *Flower-stalk* from the axil of one

Plate I.

Acokanthera Venenata. G. Don.

of the scale leaves, 0.3–0.6 m. long, compressed, bearing a dense umbel of flowers 7–13 cm. in diameter. *Flowers* subtended by 5–8 reddish-brown spathe-valves. *Perianth* 2.5 cm. or more long, pink, cylindric below. *Fruit* a sub-globose red berry containing 1–3 seeds.

The species is recorded from Natal and East Griqualand, known as the "blood flower" or "snake lily."

According to Juritz, the plant contains a non-crystallizable substance which produces vomiting.

Haemanthus punicus, Linn.

Bulb sub-globose, 5–8 cm. in diameter; scale-leaves orbicular. *Leafy stem* not produced. *Leaves* 2–4, up to 15 or 23 cm. long, undulate, produced at the base into a petiole, bright green in colour. *Flower-stalk* lateral, 15–30 cm. long, bearing a globose umbel of flowers about 8 cm. in diameter. *Flowers* subtended by 6–8 oblong spathe-valves. *Perianth* about 3 cm. long, pale scarlet, rarely white, cylindric below. *Fruit* a bright-red globose berry.

Found in the Humansdorp, Port Elizabeth, Komgha, and Somerset East districts, also in Tembuland and Pondoland.

The plant contains a poisonous alkaloid.

2. Buphane disticha, Herb.

Bulb 15–20 cm. in diameter, covered with numerous papery tunics. *Leaves* 8–16, in 2 ranks, 30–45 cm. long, strap-shaped, closely ribbed, hairy on the margins. *Flower-stalk* 15–30 cm. long, stout, biconvex in cross-section, bearing a large umbel of flowers. *Flowers* subtended by 2 spathe-valves. *Perianth* 2.5–4 cm. long, with a funnel-shaped or sub-cylindric tube. *Fruit* a turbinate capsule.

Widely distributed in South Africa. Known as the "gifbol."

The bulb contains alkaloids. A dose of 0.008 grammes per kilo body-weight kills a guinea-pig in 10 minutes.

APOCYNACEAE.

Trees, erect or scandent shrubs, rarely annual herbs, more or less laticiferous. *Leaves* simple, generally opposite, sometimes whorled, rarely alternate. *Stipules* often present. *Inflorescence* cymose. *Flowers* small to large, often showy, bisexual, regular. *Sepals* usually 5. *Corolla* glabrous or more or less hairy within. *Stamens* 5, very rarely 4, inserted on the corolla-tube; anthers frequently conniving in a cone, produced or 2-lobed at the base. *Ovary* superior, 1–2-chambered or sometimes the gynaecium of 2 free carpels. *Fruit* a berry, drupe, or of follicles. *Seeds* very often with a tuft of hairs at one or both ends.

Genera about 180, with over 1,000 species; 13 genera and 29 species are found in South Africa.

Many species in the family are reported as poisonous.

3. Acokanthera venenata, G. Don.—[Plate I.]

A shrub or small tree. *Leaves* opposite, 3.5–10 cm. long, 2–5 cm. broad, usually ovate or elliptic, dark green, and shining. *Inflorescence* a sessile or stalked axillary corymb. *Flowers* white or tinged with pink, usually sweet-scented. *Calyx* small. *Corolla-tube* 0.9–1.3 cm. long, hairy within; lobes about 3 mm. long, broadly-ovate. *Anthers* produced into a short

hairy point. *Ovary* 2-chambered, with 1 ovule in each chamber ; stigma with a ring of papillae at the base and a minutely 2-lobed hairy apiculus. *Fruit* a globose or ellipsoid berry, at first reddish then dark-purple when ripe.

Commonly known as the "gif boom"; extends from tropical Africa through the Transvaal and Natal and the coastal belt to Mossel Bay.

The plant contains a very poisonous glucoside resembling quabine. The attractive plum-like fruit have proved fatal to humans.

4. Nerium Oleander, Linn.

A tall shrub or small tree. *Leaves* in whorls of 3, up to 10 cm. long, lanceolate, stiff, dark green. *Flowers* in terminal cymes, white or rose-coloured. *Corolla* salver-shaped, with a funnel-shaped tube. *Stamens* 5, attached to the middle of the corolla-tube. *Carpels* 2, distinct. *Fruit* of 2 distinct follicles.

Native of the Levant. Is found cultivated as an ornamental plant in South Africa under the name of "oleander" or "Ceylon rose."

Feeding tests carried out in America have proved that the leaves are poisonous to stock.

COMPOSITAE.

Herbs, shrubs, rarely trees. *Leaves* alternate, more rarely opposite or whorled, simple, more rarely compound. *Flowers* in heads. *Heads* surrounded by an involucre, terminal or axillary, solitary or variously grouped. *Receptacle* smooth, honeycombed, setose, or covered with paleae. *Involucral bracts* in 1 to many rows, free or connate. *Flowers* usually bisexual, either all discoid or some forming rays. *Corolla* tubular, usually with 4–5 lobes. *Stamens* as many as the corolla-lobes, inserted on the corolla-tube ; anthers connate to form a tube round the style. *Ovary* inferior, 1-chambered, with a solitary ovule ; style filiform, usually divided into 2 style-branches. *Pappus* various, of bristles or paleae or of both or more rarely absent. *Fruit* a small achene, usually crowned with the pappus when present.

A very large and cosmopolitan family of about 900 genera and over 13,000 species. The *Compositae* is the dominant family in the South African flora.

5. Dimorphotheca spectabilis, Schltr.—[Plate II.]

A herbaceous plant 20–40 cm. high, with the stems arising from an underground rootstock. *Stems* faintly furrowed, covered with short glandular hairs. *Leaves* 2–4 cm. long, 0.6–1 cm. broad, lanceolate or lanceolate-ovate, tapering upwards, punctate-glandular on both surfaces, with glandular hairs beneath, ciliate with glandular hairs. *Flower-heads* solitary at the ends of peduncles, 6–10 cm. long. *Involucral bracts* in 2 rows, somewhat connate at the base. *Disc florets* many, with dark tips. *Rays* mauve-coloured. *Achenes* flattened, orbicular, with a circular wing. *Pappus* none.

Recorded from the Pretoria, Witwatersrand, Heidelberg, and Barberton districts of the Transvaal.

The leaves contain prussic acid, and have been proved poisonous to sheep.

Dimorphotheca Zeyheri, Sond.

Dwarf perennial, with annual shoots springing from an underground rootstock. *Stems* scaberulous. *Leaves* 2.5–6 cm. long, 0.2–1 cm. broad,

K. A. Lansdell.

Plate II.

Dimorphotheca Spectabilis. Schltr.

Plate III.

Matricaria Nigellaefolia.

linear to oblong, obtuse, entire, toothed or lobed, scabrous. *Flower-head* solitary, on a short peduncle, 4 cm. in diameter, including the rays. *Disc florets* many, producing flattened achenes. *Ray florets* yellow, producing 3-angled achenes. *Pappus* none.

Recorded from the Prieska, Kimberley, and Middelburg districts of the Cape Province. Commonly known as "jakhalsbos" or "bietou."

Poisonous to sheep.

6. Geigeria passerinoides, Harv.

An acaulescent plant or a plant producing annual shoots from an underground rootstock. *Leaves* crowded, up to 10 cm. long, 1–5 mm. broad, linear. *Flower-heads* usually in the forks of the branches, sessile. *Involucral bracts* in several rows; the outer produced into foliaceous appendages; the inner lanceolate, ciliate at the apex. *Disc florets* many. *Ray florets* yellow. *Achenes* villous. *Pappus* of paleae; the alternate paleae produced into awns.

A species widely distributed in the Karroo area; recorded from Beaufort West, Murraysburg, Graaff-Reinet, Cradock, Herbert, Kimberley, Barkly West, Bloemfontein, and Vryburg districts, and extends into South-West Africa. Known as the "vermeerbossie."

Causes the disease "vermeersiekte" in cattle, sheep, and goats.

7. Matricaria nigellaefolia. DC.—[Plate III.]

A herbaceous plant growing in marshy places. *Stems* 30–60 cm. long, usually decumbent, often rooting where they touch the soil. *Leaves* 2.5–4 cm. long, much dissected. *Flower-heads* 5–7 mm. in diameter, more or less globose, solitary at the ends of peduncles 1.5–3 cm. long. *Involucral bracts* in 2 rows. *Disc florets* many. *Ray florets* short, white. *Pappus* none.

Recorded from the Komgha, Stockenstrom, East London, and Queenstown districts of the Cape Province, also in parts of Natal and Zululand. Common name "Stagger's weed."

Causes a disease known as "bovine staggers" in cattle.

8. Pteronia pallens, Linn.

A small bush up to 0.6 m. high. *Branches* glabrous, with greyish white bark. *Leaves* opposite, slightly connate at the base, 1–3 cm. long, about 1 mm. thick, linear, obtuse. *Flower-heads* 11–12-flowered, about 1.3 cm. long, solitary on very short peduncles. *Involucral bracts* in about 6 rows; all rounded at the apex and shortly ciliate. *Ray florets* absent. *Achenes* densely hairy, crowned with a light straw-coloured pappus of stiff bristles.

Found in the Calvinia, Ceres, Kimberley, Laingsburg, Prince Albert, Middelburg, Oudtshoorn, Mossel Bay, and George districts of the Cape Province. Known as the "witbossie," "witgat bossie," or "Scholtzbossie."

Poisonous to sheep.

9. Senecio Burchellii, DC.—[Plate IV.]

A sub-herbaceous annual, sometimes forming a small bush up to 0.5 m. high. *Stems* finely striate. *Leaves* usually 2–5 cm. long, sometimes up to 13 cm. long, 1–1.5 mm. broad, linear, entire or sometimes with outgrowths at right angles to the margins. *Flower-heads* arranged more or less in a

Plate IV. *Senecio Burchellii*, DC. K. A. Lansdell.

Plate V.

Senecio Ilicifolia. Thunb.

corymb. *Heads* 1–1.2 cm. in diameter (excluding the rays). *Involucral bracts* many, linear, with a membranous margin. *Disc florets* about 40. *Ray florets* about 5–7, yellow. *Achenes* minutely hairy, crowned with a pappus of fine bristles.

Recorded from the Cape Peninsula and eastwards through the south-eastern districts; also from the Ceres, Middelburg, and Prieska districts and from Natal.

The seeds are toxic, and when accidentally harvested with wheat from which meal has been prepared, have been the cause of human poisoning in the George district of the Cape Province.

Senecio ilicifolius, Thunb.—[Plate V.]

A herbaceous plant, up to 1 m. high, shrubby at the base. *Stems* finely striate, glandular-pubescent. *Leaves* sessile, clasping the stem, 2.5–4 cm. long, gradually decreasing in size upwards, 0.3–1.2 cm. broad, lanceolate, acuminate, acute, sharply and coarsely toothed, scabrous above, white-woolly beneath. *Flower-heads* in a large lax corymbose panicle. *Heads* 1 cm. in diameter (excluding the rays). *Involucral bracts* many, linear. *Disc florets* 50–60. *Ray florets* about 12, yellow. *Achenes* minutely granulated, crowned with a pappus of fine bristles.

Common in the south-western districts of the Cape Province.

The seeds are toxic in the same way as those of *Senecio Burchellii*.

Senecio latifolius, DC.—[Plate VI.]

A herbaceous perennial, with cylindric fleshy roots. *Rootstock* hairy at the crown. *Stems* up to 60 cm. long, ribbed. *Leaves* 4–13 cm. long, 1–3.5 cm. broad, decreasing in size up the stem, more or less clasping the stem, lanceolate or lanceolate-ovate, shortly acuminate, acute, cordate at the base, minutely and remotely toothed, veiny, glabrous. *Flower-heads* in a large lax terminal panicle. *Heads* 5.6 mm. in diameter. *Involucre* usually forming an inverted cone. *Disc florets* 10–12. *Ray florets* 3–5. *Achenes* glabrous, crowned with a pappus of fine hairs.

A widely spread species in the Union, extending from the Uitenhage and Albany districts through the Transkei into Natal. It is also found in the country north of the Stormberg Range and in parts of the Transvaal. There is some doubt whether all the plants commonly named *S. latifolius* really belong to this species. Known as "Dan's cabbage" and "Molteno disease plant."

Two toxic alkaloids, *senecifoline* and *senecifolidine*, have been isolated. The plant produces a disease in horses known as "Molteno disease."

CRASSULACEAE.

Herbs or undershrubs, often fleshy or succulent. *Leaves* opposite or alternate, frequently in basal rosettes and the leaves of opposite pairs frequently connate at the base, usually simple. *Stipules* 0. *Flowers* very often cymose, bisexual, very rarely unisexual, regular. *Calyx* persistent, usually 3–5-partite. *Petals* as many as the sepals, free, or more or less connate. *Stamens* as many as or twice as many as the petals. *Gynaecium* of free carpel, very rarely carpels fused, with glands at the base of each carpel. *Fruit* of free follicles, very rarely a capsule.

Sixteen genera, with over 400 species, of which 8 genera and more than 300 species occur in South Africa. The family does not contain many species considered as poisonous.

10. Cotyledon orbiculata, Linn.—[Plate VII.]

A low shrubby somewhat succulent plant. *Stem* with a light brown bark. *Leaves* opposite, 6.5–8 cm. long, 4–4.5 cm. broad, obovate, sub-acute,

Plate VI. *Senecio latifolius*, DC. [K. A. Lansdell.

Plate VII.

Cotyledon Orbiculata, Linn.

glabrous, with red margins. *Peduncle* up to 27 cm. long, circular in cross-section, reddish in colour, bearing at the summit a panicle of cymes. *Calyx-tube* almost none; lobes 5 mm. long, ovate, acute. *Corolla-tube* 2.8 cm. long; lobes 2 cm. long, oblong, obtuse. *Stamens* 10. *Gynaecium* of free carpels.

The species has a wide distribution in South Africa and is represented by many forms. Recorded from the Cape, Uitenhage, Queenstown, and East London districts; also from Basutoland and the Transvaal. Commonly known as "hondeoor," "varkoor," or "pig's ears."

Causes paralysis in fowls, which sometimes ends in death. May also have fatal results if fed to sheep.

Cotyledon paniculata, Thunb.

Stems 30–60 cm. high, thick and fleshy; branches, when present, short, thick, tubercled, with prominent leaf-scars. *Leaves* 5–8 cm. long, 2.5–3.5 cm. broad, tapering to a narrow base, deciduous. *Peduncle* (including the inflorescence) 30–60 cm. long. *Flowers* in a lax panicle. *Calyx* less than half as long as the corolla, minutely hairy. *Stamens* 10. *Gynaecium* of free carpels.

A species of the Little Karroo. Known as "botterboom." Produced laminitis in kids, but did not prove fatal.

Cotyledon reticulata, Thunb.

Stem 11–21 in. high, simple or once or twice divided, succulent, smooth, or covered with wart-like abortive branches. *Leaves* several in a tuft, 4–8 mm. long, 2 mm. in diameter, almost fusiform. *Peduncles* many from the stem, much dichotomously branched, forming a spiny cap to the stem, about 7 cm. long and 18 cm. in diameter. *Flowers* solitary on slender pedicels, 1.5–2.5 cm. long. *Calyx* half as long as the corolla, somewhat viscid. *Corolla* 8–10 mm. long, pale, somewhat viscid. *Stamens* 10. *Gynaecium* of free carpels.

A Karroo species, but also recorded from Little Namaqualand. Known as "ou-koe." Causes partial paralysis in fowls, but not fatal.

Cotyledon Wallichii, Harv.

Stem fleshy, branched, up to 30 cm. high, covered with protuberences of old leaf-scars. *Leaves* crowded at the ends of the branches, 5–8 cm. long, circular in cross-section, glabrous, deciduous. *Flowers* in a panicle. *Calyx* less than half as long as the corolla, nearly free. *Corolla* 1.9 cm. long, greenish-yellow. *Stamens* 10. *Gynaecium* of free carpels.

Has a fairly wide distribution in the Karroo. Known under the names of "bandjies bos," "kandelaarbos," "nenta-bos," or "krimpsiekte bos."

Causes a disease known as "nenta or krimpsiekte" in sheep and goats.

CUCUBITACEAE.

Herbs or undershrubs, prostrate or scandent, smooth, scabrid, or pubescent. *Leaves* alternate, petioled, simple, lobed, or pinnatisect, with tendrils from their axils. *Flowers* unisexual, usually white or yellow, often flowers solitary, or inflorescence a panicle, rarely a raceme or subumbel. *Calyx* 5-, rarely 3-6-lobed. *Petals* 5, rarely 3-6. *Stamens*

free or joined, usually 3, rarely 1, 2, or 5; anthers straight, curved, or flexuose. *Ovary* inferior, usually 3-chambered; style simple, or divided at the apex. *Fruit* usually a berry or gourd.

Genera 96, with over 700 species found in all warm countries; 18 genera, with over 80 species, are recorded from South Africa.

Several species are reported as irritants, some contain saponin, others are used as emetics and fish poisons.

11. Melothria punctata, Cogn.

A creeping herbaceous plant. *Leaves* 3–6.5 cm. apart, 2–5 cm. long, 1.5–4 cm. broad at the base, ovate, mucronate at the apex; cordate at the base, toothed on the margins, scabrous above, hairy beneath, with the veins diverging from the apex of the petiole. *Tendrils* simple. *Flowers* unisexual, borne at the same node as the leaf, fascicled, or inflorescence a corymb or raceme. *Calyx* campanulate or tubular, 5-toothed or -lobed. *Corolla* 5-partite. *Stamens* 3. *Ovary* globose or fusiform; stigmas 2–3-lobed or sometimes with 3 linear dilated stigmas. *Fruit* a small globose berry, few-seeded.

Recorded from many districts in the Cape Province and from Harrismith in the Orange Free State. Known as "davidjies wortel."

Sheep fed on the leaves showed no visible ill-effects, but an infusion given as an intravenal injection proved fatal.

DICHAPETALACEAE.

Trees or shrubs, sometimes acaulescent. *Leaves* alternate, petioled, entire. *Stipules* present. *Flowers* bisexual or unisexual; inflorescence a corymbose cyme. *Sepals* 5, free or connate. *Petals* 5, free and equal or connate and unequal. *Disc* of free glands or connate into a cup. *Stamens* 5, free or adnate to the corolla. *Ovary* superior, 2–3-chambered, hairy. *Fruit* a drupe.

Genera 3, with about 90 species; natives of Asia, Africa and America. A single species is found in South Africa.

12. Dichapetalum cymosum, Hook.—[Plate VIII.]

An acaulescent plant with shoots from a deep underground rootstock. *Branches* hairy, leafy towards the apex. *Leaves* 7–12 cm. long, 1.5–5 cm. broad, lanceolate or elliptic-lanceolate, glabrous or hairy. *Flowers* in peduncled cymose panicles shorter than the leaves. *Calyx-lobes* hairy. *Petals* deeply bifid, as long as the calyx-lobes. *Stamens* 5. *Glands* 5, opposite the petals. *Ovary* 3-chambered; styles 3. *Fruit* a drupe.

Recorded from the Pretoria, Waterberg, and Messina districts of the Transvaal. Known as the "gifblaar."

Poisonous to cattle, sheep, and goats.

EUPHORBIACEAE.

Herbs, shrubs, or trees, often with milky juice. *Leaves* alternate, rarely opposite, or in whorls of 4, simple or rarely compound, sometimes rudimentary. *Stipules* present or 0. *Flowers* usually small, unisexual. *Perianth* occasionally absent from one or both sexes. *Male flowers:* *Stamens* definite or indefinite; filaments free or connate. *Female flowers:*

Plate VIII.

Dichapetalum Cymosum, Hook.

Ovary superior, usually 3-chambered; styles free or more or less connate. *Disc* annular, entire, or of free scales, or 0. *Fruit* usually a capsule, sometimes a drupe.

Genera about 250, with about 4,000 species, mostly found in the tropics of both hemispheres; 239 species are recorded from South Africa.

The family contains very many poisonous species, and in cases of poisoning, any member of the family should be regarded with suspicion. Several species of *Euphorbia*, however, are excellent stock-food plants.

13. Toxicodendron capense, Thunb.

A shrub or small tree. *Leaves* in whorls of four, 6–11 cm. long, 1.3–3 cm. broad, lanceolate, gradually narrowed to the base, entire, glabrous when adult. *Male flowers* in axillary cymes, very much shorter than the leaves. *Petals* absent. *Stamens* numerous. *Female flowers* 1–3 between each leaf-axil. *Ovary* ovoid, hairy; styles 3–5, connate in the lower half, with the free portions thick and densely papillose. *Fruit* a capsule, about 2.5 cm. in diameter, usually 4-locular, somewhat globose, 8-lobed. *Seeds* black and shining.

Found on the mountains in the Van Rhynsdorp and Clanwilliam districts. Known under the names of "boesman's gif," "gifboom," "wolwegif," and "wolweboontjie."

The seeds contain the very powerful and very bitter principle "hyaenanchine."

GRAMINEAE.

Usually annual or perennial herbs. *Stems* nearly always branched at the base, rarely simple, thus forming fascicles or tufts, ascending, prostrate or creeping. *Culms* usually hollow at the internodes. *Leaves* alternate, usually 2-ranked, often crowded, usually sheathed at the base, with a free blade and a ligule at the junction of the blade and sheath. *Inflorescence* terminal, built up of variously arranged spikelets. *Spikelets* consisting of glumes, valves, pales, and flowers, sometimes one or more of these suppressed. *Stamens* usually 3, on long very slender filaments. *Ovary* superior, 1-chambered; styles usually 2, feathery. *Fruit* a grain.

Genera over 325, with close on 4,000 species, found in all parts of the world; almost a third of the known genera occur in South Africa.

14. Setaria sulcata, Raddi.

A perennial grass. *Culms* stout, 1.6–4 m. high, compressed below, sometimes hairy and scabrid close to the panicle, 5- or more noded, sheathed all along or the upper internodes exserted. *Sheaths* long, rather tight, glabrous or hairy, with a ciliate rim at the junction with the blade; blade 0.3–1 m. long, 2.5–8 cm. broad, plicately folded when young, lanceolate to linear-lanceolate, much narrowed towards the base. *Inflorescence* a panicle, 0.3–1 m. long.

Found in the eastern districts of the Cape Province and in Natal. Known as the "buffalo grass."

The seeds have been proved poisonous to small birds.

15. Sorghum sudanense, Stapf.

An annual. *Culms* 2–3.3 m. high, about 9-noded, glabrous. *Leaf sheaths* finely and densely silky, hairy at the nodes, with a membranous ligule at the junction with the blade; blade 15–30 cm. long, up to 1.5 cm. broad, long-attenuated towards the base. *Inflorescence* a raceme.

Cultivated under the name of Sudan grass.

At certain stages of growth the leaves are poisonous to cattle. This applies also to some other species of *Sorghum*.

IRIDACEAE.

Perennial herbs, usually having a corm as an underground stem. *Leaves* narrow, sessile, firm in texture, persistent, often equitant and distichous, often in a basal rosette. *Inflorescence* a simple or branched spike, corymb, or panicle. *Flowers* 1 or more to each spathe, bisexual, regular or irregular. *Spathe-valves* green and herbaceous, scarious, or membranous, sometimes lacerated. *Perianth-tube* cylindric or funnel-shaped: segments longer or shorter than the tube. *Stamens* 3, unilateral or equilateral; filaments free or connate. *Ovary* inferior, usually 3-chambered; style filiform; style-branches 3, filiform, subulate, or flattened, sometimes petaloid, entire or bifid. *Fruit* a 3-locular capsule.

Genera about 60, with nearly 700 species; found in the temperate regions of both hemispheres. Over half of the known species occur in South Africa.

Species of *Iris* supply "orris root," and the stigmas of *Crocus sativa* yield saffron or crocus. The family generally is not a poisonous one.

16. Homeria pallida, Bkr. (*National Herbarium No.* 2281).

Corm globose, about 1.5 cm. in diameter, with hard brown-black tunics. *Produced leaf* 1, arising from near the base of the stem, about twice as long as the stem, linear, closely ribbed. *Flowers* in 2–3 clusters. *Spathes* cylindric, 4–5 cm. long, ribbed, produced into long cusps. *Perianth* pale yellow; segments sub-equal, oblanceolate-oblong, obtuse. *Stamens* half as long as the perianth. *Ovary* about 1 cm. long, club-shaped. *Capsule* about 1.3 cm. long, more or less club-shaped.

Distributed over Bechuanaland, the western Transvaal, and the western portion of the Orange Free State. Recorded from the Vryburg, Prieska, Ermelo, Heidelberg, Potchefstroom, Waterberg, and Bloemfontein districts.

Known as the "Transvaal yellow tulp."

Poisonous to cattle.

17. Moraea polystachya, Ker, var. brevicaulis.

A plant about 0.6 m. high. *Produced leaves* about 4, about as long as the stem, linear, 5–7 mm. broad, closely ribbed. *Flowers* in a lax corymb of 4–6 clusters. *Spathes* 2–4-flowered, 4–5 cm. long, finely acuminate. *Perianth* lilac; outer segments 2.5 cm. long, clawed; inner-segments narrower than the outer. *Filaments* connate at the base. *Style-branches* large, lanceolate. *Capsule* more or less club-shaped.

Recorded only from the Albany district. Known, with other species, as the "blou tulp."

Feeding tests have shown that this tulp is poisonous to cattle.

Moraea rivularis, Schltr.

An erect plant 0.8–0.9 m. high. *Leaf* solitary at the base of the stem, 1 cm. broad, linear, glabrous, nerved, almost as long as the stem. *Flowers* usually few. *Spathe* erect, herbaceous, acute. *Pedicels* as long as or shorter than the spathe. *Perianth* yellow; outer segments 4.3 cm. long, 1.3 cm. broad above the middle, oblanceolate-oblong, clawed at the base; inner-segments 3.5 cm. long, 0.6 cm. broad about the middle, oblanceolate-linear, obtuse. *Filaments* glabrous, united below. *Style-branches* bipartite, semi-elliptic, slightly crenulate, much shorter than the inner perianth-segments. *Ovary* cylindric, on a slender pedicel.

Found in Natal.

Poisonous to cattle.

Plate LX.

Abrus Precatorius, Linn.

Moraea sp. (*National Herbalium No.* 1057).

This plant has not been specifically determined, as the material is insufficient. It is near *M. spathacea*, Ker.

Found in East Griqualand.

Feeding tests have proved this plant to be poisonous to stock.

LEGUMINOSAE.

Trees, shrubs, or herbs of varying habit. *Flowers* regular or irregular, bisexual, or bisexual with occasional unisexual flowers. *Leaves* alternate or rarely opposite, simple or compound. *Stipules* usually present. *Sepals* free or variously connate. *Petals* 5, or fewer by abortion, irregular or regular. *Stamens* twice as many as the petals, more rarely equalling the petals, or fewer by abortion, sometimes numerous; filaments free or variously connate. *Ovary* superior, 1-chambered; style simple; stigma usually simple. *Fruit* usually a legume, rarely a drupe, sometimes indehiscent.

Genera about 489, with about 11,000 species; distributed all over the world, somewhat rare in New Zealand, absent from the Antarctic regions. The Leguminosae is one of the dominant families in South Africa, and in all the floral regions of the Union it ranks second or third in importance, except in the Western region, where it only occupies the fifth place.

The family is one of the most important economic families of plants and supplies innumerable commodities for human use. It also contains many poisonous species, and 300 such are mentioned by Pammel.

18. Abrus precatorius, Linn.—[Plate IX.]

A sub-woody climber. *Leaves* 6–8 cm. long, pinnate; stipules subulate; rhachis produced into a fine point beyond the last pair of leaflets; leaflets in about 11 pairs, 0.6–1.5 cm. long, 3.5–7 mm. broad, oblong, very shortly mucronate, glabrous or very minutely and finely hairy. *Flowers* in axillary racemes up to 5 cm. long. *Calyx* scarcely produced into lobes, finely hairy. *Petals* reflexed, 7 mm. long, glabrous. *Fruit* about 3 cm. long, 1.3 cm. broad, hairy and tuberculate. *Seeds* scarlet with a black area at one end.

A common plant in the northern Transvaal, Natal, and Zululand. Also occurs in India, Australia, and is generally distributed through the tropics. Known as "love beans" or "lucky beans."

The seeds contain abric acid. When a tincture is injected into an animal, death follows within a very short period.

19. Cassia obovata, Coll. (*National Herbarium No.* 2882).

A low shrub, up to 30 cm. high. *Leaves* 5–11 cm. long, pinnately compound; stipules 6 mm. long, lanceolate, acuminate; leaflets in 4–6 pairs, 1.2–3 cm. long, 0.6–1.5 cm. broad, oval, rounded at the apex, with distinct veins, glabrous. *Flowers* yellow, in axillary racemes longer than the leaves. *Calyx* glabrous. *Petals* sub-equal. *Stamens* 10, unequal. *Ovary* glabrous. *Fruit* a more or less kidney-shaped membranous pod, 3.5 cm. long, 1.8 cm. broad, oblique at the apex, tipped with the remains of the style.

Recorded from the Vryburg, Kimberley, Bloemhof, Malelane, Fauresmith, Boshof, and Hebron districts. Known as "wild senna."

Feeding tests have proved this species poisonous to stock.

20. Crotalaria burkeana, Benth.—[Plate X.]

A small bush, about 30 cm. high. *Branches* covered with long brown hairs. *Leaves* 3-, rarely 5-foliate, on hairy petioles, 1.5–3 cm. long; leaflets 1–4 cm. long, 2–7 mm. broad, linear to lanceolate, hairy, with long lax

hairs. *Flowers* in racemes. *Calyx* 1.5 cm. long, hairy with long lax hairs; lobes acuminate. *Petals* yellow, 2 cm. long; vexillum streaked with dark hairs. *Stamens* 10. *Ovary* hairy. *Fruit* a pod, up to 5 cm. long, 1.5 cm. in diameter, inflated, covered with long weak hairs from a bulbous base, tipped with the persistent style.

Widely distributed in the western Transvaal and parts of Bechuanaland; also recorded from the Pretoria, Pietersburg, and Barberton districts and from the north-western Free State. Commonly known as "klappers," "rattle-bush," or "styfsiektebos."
Causes a disease known as styfsiekte in cattle.

Crotalatia dura, Wood and Evans—[Plate XI.]

A low spreading bush. *Leaves* 3-foliate; petiole about 5–7 mm. long; leaflets 1–3.5 cm. long, 0.25–2 cm. broad, lanceolate or oblanceolate, more rarely linear or obovate, obtuse, more rarely sub-acute at the apex, glabrous or finely pubescent beneath. *Flowers* in terminal racemes, 2–8 cm. long. *Pedicels* 5 mm. long. *Calyx* 6 mm. long, hairy; lobes acuminate. *Petals* yellow, 8 mm. long; vexillum ciliated on lower part of the margin. *Stamens* 10. *Ovary* hairy. *Fruit* a sub-globose pod, 1 cm. long, 8 mm. in diameter, tipped with the persistent style, finely hairy.

Appears to be confined to Natal. Known as the "jagsiekte bossie."
Causes the disease "jagsiekte" in horses and cattle.

Crotalaria globifera, E. Mey.

A small bush. *Leaves* 3-foliate; petiole 0.7-1.5 cm. long, glabrous or minutely hairy; leaflets 1.2–3 cm. long, 2–8 mm. broad, linear to oblong-elliptic, minutely hairy. *Flowers* in terminal racemes 6–8 cm. long. *Pedicels* finely hairy. *Calyx* hairy, with long acuminate lobes. *Corolla* yellow, about 1 cm. long; keel beaked. *Stamens* 10. *Ovary* globose, hairy; style hairy above. *Fruit* a spherical pod, about 6 mm. in diameter, finely and densely hairy.

Found in Natal, but is also recorded from the Pretoria district.
When fed to horses produces fatal results.

21. Erythrophloeum lasianthum, Corbishley.

A large tree. *Leaves* bipinnate; pinnae opposite, 12–15 cm. long; leaflets in 5–6 pairs, 4–5 cm. long, 1.5–2 cm. broad, obliquely ovate, emarginate at the apex, unequally rounded at the base, with the margins slightly undulate, glabrous and shining on both surfaces, with the mid-rib conspicuous. *Flowers* in lax panicles. *Peduncle* hairy. *Sepals* about 2.5 mm. long, oblong, obtuse, hairy. *Petals* 4 mm. long, oblong-spathulate, hairy without. *Stamens* 10; filaments densely woolly-pilose. *Ovary* stalked, densely woolly. *Fruit* a pod, 9.5–14.5 cm. long, 3.5–4.2 cm. broad, slightly curved, rounded at the apex.

Found in Natal and Zululand.
Fatal results when fed to sheep.

22. Lessertia brachystachya, DC.

A small shrub. *Leaves* 3–9 cm. long, pinnately compound; leaflets in 6–9 pairs, 0.5–15 cm. long, 1.5–4 mm. broad, linear or oblong, obtuse, finely hairy. *Flowers* in axillary racemes shorter than the leaves. *Calyx*

Plate X.

Crotalaria Burkiana, Benth.

Plate XI.

Crotalaria Dura. W. & E.

hairy. *Vexillum* 8 mm. long, glabrous. *Stamens* 10. *Ovary* hairy. *Fruit* a membranous pod, 3.5 cm. long, 7 mm. broad, linear, tipped with the remains of the style.

A plant of the eastern districts, being recorded from the Kingwilliamstown, Bathurst, Humansdorp, and Komgha districts.

Feeding experiments have shown that this species is poisonous to stock.

23. Mundulea suberosa, Benth.

A small tree. *Leaves* 5.5–12 cm. long, pinnately compound; leaflets in 5–7 pairs, 1–5 cm. long, 0.5–1.2 cm. broad, elliptic to lanceolate, rounded or acuminate at the apex, silky. *Flowers* blue, in racemes shorter than the leaves. *Peduncle* densely hairy. *Calyx* hairy. *Vexillum* 1 cm. long, hairy without. *Stamens* 10. *Ovary* linear, silky. *Fruit* 5.5–8 cm. long, 8 mm. broad, tomentose, usually beaked.

Recorded from the Heidelberg, Witwatersrand, Pretoria, Waterberg, Rustenburg, and Pietersburg districts of the Transvaal; also found in Bechuanaland, Swaziland, and Portuguese East Africa.

According to Pammel a very toxic unnamed glucocide occurs in the bark and roots.

24. Phaseolus lunatus, Linn.

A twining plant. *Leaves* pinnately 3-foliate; stipules 5 mm. long, ovate, ribbed; petiole 2.5–8 cm. long; leaflets 4–9 cm. long, 2.2–9.5 cm. broad at the base, ovate, acute, usually obscurely lobed, very minutely hairy; stipellae 2.5 mm. long, oblong. *Flowers* in racemes on long axillary peduncles up to 24 cm. long. *Pedicels* 1 cm. long, hairy. *Bracts* 5 mm. long, oblong. *Calyx* hairy. *Petals* 1.5 cm. long, glabrous or sparsely hairy; keel twisted. *Stamens* 10. *Ovary* hairy; style hairy above. *Fruit* 4–8 cm. long, 1.5–1.7 cm. broad, straight or curved, beaked.

Cultivated in South Africa.

The roots have been reported as poisonous to humans (reports from Transvaal and Transkei). According to the Imperial Institute (*Bull.*, 1903, p. 115), the seeds may produce prussic acid.

25. Tephrosia macropoda, Harv.

A prostrate shrub. *Stems* sparsely hairy. *Leaves* usually trifoliate, but sometimes with a pair of leaflets below the upper three; petiole 3–7 cm. long, sparsely villous; leaflets 2.7–6 cm. long, 1–2.5 cm. broad, elliptic-lanceolate to almost orbicular, usually mucronate at the apex, glabrous above, sparsely pilose beneath, closely ribbed on both surfaces. *Stipules* large. *Flowers* 2–4 at the end of a peduncle up to 30 cm. long. *Calyx* glabrous or sparsely pubescent. *Vexillum* silky without. *Stamens* 10. *Fruit* a pod, 5.5 cm. long, 8 mm. broad, linear, tipped with the remains of the style, ciliated on both margins.

Found in Natal and Zululand, in the Barberton and Middelburg districts of the Transvaal, and in Komgha and Tembuland in the Cape Province.

Used as a fish poison.

Tephrosia Vogelii, Hook.

A shrub (?). *Leaves* up to 19 cm. long, divided into about 12 pairs of leaflets; leaf-rhachis densely hairy; leaflets 5 cm. long, 1.2 cm. broad, oblong, obtuse, shortly apiculate, densely silky-hairy on both surfaces, with the lateral nerves distinct beneath. *Flowers* 2.5 cm. long, in a large terminal raceme up to 10 cm. long. *Calyx tube* and *lobes* densely hairy

Vexillum densely hairy without. *Stamens* 10. *Ovary* hairy. *Fruit* a pod up to 13 cm. long, 1.5 cm. broad, linear, tipped with the remains of the style, velvety, with a dense covering of brown hairs.

Found in many parts of the Transvaal, Natal, Rhodesia, and Portuguese East Africa. Used by the natives as a fish-poison. Rabbits eat the leaves with impunity, but an injection of 0.01 grammes per kilo body-weight produces death (*Bull. Imperial Instit.*, 1915, p. 61).

LILIACEAE.

Rootstock usually a bulb, more rarely a corm, tuber, or rhizome, usually stemless, sometimes shrubby or aborescent or climbing. *Leaves* various, mostly radical, sometimes appearing after the flowers. *Inflorescence* a raceme, panicle, corymb, or spike, more rarely a head or umbel. *Flowers* bisexual, rarely unisexual, regular or nearly so. *Perianth* petaloid, of 6 free segments, or segments joined to form a long or short tube. *Stamens* 6, opposite the perianth-segments. *Ovary* superior, 3-chambered, with 1–2 to many ovules in each chamber; style simple or styles distinct. *Fruit* a capsule or berry.

Genera over 200, with more than 2,000 species, widely distributed all over the world. In South Africa 53 genera, with almost 900 species, are recorded. The family is an important one in South Africa, and the species of *Liliaceae* form on the average 6.1 per cent. of the total species of plants.

The Liliaceae in general must be considered a poisonous family. Such well-known plants as *Urginea scilla* (squills), containing scillitoxin and scillipian, *Aloe socotrina* and *A. ferox* containing aloin, *Colchicium autumnale* (meadow saffron) containing the alkaloid cochicin, belong to the family. Many species, e.g. *Asparagus officinalis* (asparagus), *Allium cepa* (onion), *A. sativum* (garlic), are cultivated as vegetables, while many species are cultivated garden plants.

26. Agapanthus umbellatus, L'Her.

Rootstock tuberous, with fleshy cylindric roots. *Leaves* 6–8, 0.3–0.6 m. long, 2.5–4 cm. broad, strap-shaped. *Peduncle* 0.3–1.2 m. long, cylindric, bearing at its summit an umbel of blue flowers. *Flowers* 30–50 in the umbel, 3.5–5 cm. long, on pedicels 3.5–8 cm. long which articulate at the apex. *Spathe-valves* 2, broad, membranous. *Fruit* a capsule, about 4 cm. long.

Found widely distributed, except in the Karroo areas. Commonly known as "agapanthus."

The plant contains the toxic principles sallitoxin and scillipiain.

27. Bowiea volubilis, Harv.

Rootstock a globose tuber, 10–15 cm. in diameter. *Produced leaves* 1–2, vanishing very early. *Stems* reaching a height of almost 2 m., copiously pinnately branched; branchlets 2.5–4 cm. long, with a minute lanceolate bract at the base. *Flowers* greenish, 1–1.5 cm. in diameter, from the ends of long curved pedicels produced from the main stem. *Fruit* a capsule, up to 1.5 cm. long.

A species mostly confined to the eastern parts of South Africa.

The tuber contains an acrid substance of strong emetic and irritant properties. Two cases of death in humans have been reported through partaking of a decoction of the tuber. Sheep and goats fed on the plant died from gastritis.

28. Gloriosa virescens, Lindl.

Rootstock tuberous. *Stems* climbing. *Leaves* in whorls of 2–4 at the middle of the stem, alternate above, ovate, with the apex produced into a tendril. *Flowers* showy, few in a corymb at the ends of the branches.

Plate XII.

Gloriosa Superba. Linn.

Plate XIII.

Ornithogalum Thyrsoides, Jacq.

Peduncles long, slender, curved near the tip. *Perianth* 3.5–5 cm. long bright red or yellow, reflexing; segments clawed. *Stamens* much shorter than the perianth-segments. *Style* about 2.5 cm. long. *Fruit* a capsule.

A species found in the eastern districts and in Natal. Known as the "superb lily." According to Medley Wood, the tubers are extremely poisonous.

Gloriosa superba, Linn.—[Plate XII.]

A plant similar to the above, but the perianth-segments are crisped instead of flat.

A Transvaal species recorded from the Barberton and Pietersburg districts. The "superb lily."

The roots, stalks, and leaves are said to contain acrid narcotic poisons, and are not infrequently used in India for suicidal purposes. The poisonous principle is superbine.

29. Ornithogalum thyrsoides, Jacq.—[Plate XIII.]

Rootstock a greenish globose bulb, 2.5–4 cm. in diameter. *Leaves* 5–6, radical, 15–45 cm. long, 1–4 cm. broad, strap-shaped, somewhat fleshy. *Pedunele* 15–45 cm. long, stiff and tough, bearing a dense raceme of white flowers with a brownish-green centre. *Flowers* 2–2.5 cm. long, campanulate. *Stamens* about one-third the length of the perianth-segments, dilated at the base. *Ovary* small; style thick and very short. *Fruit* a capsule.

A very common species in parts of the south-western area of the Cape Province. Known under the names of "chinkerichee," "wit viooltjie," "star of Bethlehem."

The plant, according to Marloth, does not contain an alkaloid or a glucocide, but a resin. Feeding tests have proved this plant to be extremely poisonous to horses, though some farmers state that their horses eat the plant without any ill-effects.

Ornithogalum tenellum, Jacq.

Very similar to the above but the flowers are pure white and the style is slender instead of short and thick.

Recorded from the Swellendam district.

Feeding tests with horses have given positive results.

30. Scilla lanceaefolia, Bkr.

Rootstock a bulb 5–8 cm. in diameter. *Leaves* 6–8, radical, 13–15 cm. long, 4–5 cm. broad at the widest part, oblong or oblong-lanceolate, acute, with blotches of dark green on a light green ground. *Peduncles* 2–5 to each bulb, 5–10 cm. long, curved, bearing a dense raceme of mauve-purple flowers. *Flowers* about 0.5 cm. long, stalked; the lower flowers curved. *Filaments* bright purple. *Ovary* globose, slightly stalked.

A widely distributed species in the Union. Known as the "wild squill."

Animals drenched with a decoction developed a slight cough, watering at the eyes, and reddening of the visible mucous membranes, but eventually recovered.

31. Urginea Burkei, Bkr.—[Plate XV.]

Rootstock a large red bulb. *Leaves* appearing after the flowers, all radical, tapering to a fine point. *Pedunele* about 30 cm. long, bearing a dense cylindric raceme. *Flowers* white, with a distinct brown keel. *Stamens* somewhat shorter than the perianth. *Fruit* a bluntly 3-lobed capsule, 1.5 cm. long.

The species is recorded from the Transvaal, especially from the south-western districts, and also from parts of Griqualand West. Known as the "Transvaal slangkop."

The whole plant is toxic to stock, but the toxicity disappears as soon as the flowers are mature. Poisoning of stock usually takes place during spring, when the plant is sometimes the only green herbage on the veld.

Urginea macrocentra, Bkr.—[Plate XVI.]

Rootstock a large globose bulb. *Leaf* solitary, appearing after the flowers, almost 1 m. long, cylindric. *Peduncle* stout, up to 1 m. high, bearing a dense cylindric raceme of flowers. *Flowers* white, with a brown keel. *Lower bracts* spurred. *Stamens* shorter than the perianth-segments.

Recorded from Natal and the Transkeian Territories. Known as the "Natal slangkop." This species is as poisonous as the "Transvaal slangkop."

MALVACEAE.

Herbs, shrubs, or trees, often softly hairy or with stellate pubescence. *Leaves* alternate, simple, entire, lobed or more rarely dissected. *Stipules* free, sometimes minute. *Flowers* usually pedicelled, axillary, solitary, regular, usually bisexual. *Epicalyx* usually present. *Calyx* usually of 5 segments. *Petals* 5, rarely absent. *Stamens* many, with the filaments united into a tube. *Gynaecium* of 2 to many free or fused carpels, arranged round a central torus; style usually branched, rarely simple. *Fruit* dry, usually breaking up into separate carpels. *Seeds* often hairy.

Genera 43, with about 800 species, widely dispersed; 15 genera, with over 90 species, recorded from South Africa.

A few species of *Malva* are used medicinally, while *Gossypium* produces the cotton of commerce. The family is not regarded as a poisonous one.

32. Malva parviflora, Linn.

A herbaceous plant with usually prostrate stems. *Stems* sparsely hairy with star-shaped hairs. *Leaves* on long petioles; petiole 2–6 cm. long, slender; blade 1.5–3 cm. long, 1.5–5 cm. broad at the base, somewhat fan-shaped or kidney-shaped, bluntly lobed, with the veins radiating from the apex of the petioles, hairy with star-shaped hairs. *Flowers* clustered in the axils of the leaves. *Petals* scarcely longer than the sepals. *Filaments* of stamens joined. *Fruit* disc-like, with raised transverse ridges and a depression in the centre, showing the remains of the style.

A naturalized weed which has been recorded from the Bloemhof and Potchefstroom districts of the Transvaal, the Cape and Albany districts of the Cape Province, and from Bechuanaland.

In Australia this plant has been proved by experimental feeding tests to produce staggers in sheep.

MELIANTHACEAE.

Trees or shrubs, sometimes undershrubs. *Leaves* alternate, imparipinnate or simple. *Stipules* present or absent. *Flowers* in terminal or axillary racemes, bisexual, or plants dioecious with occasional bisexual flowers. *Sepals* 5, free or connate. *Petals* 5 or 4. *Disc* unilateral or cupular. *Stamens* 4–10; filaments free or connate. *Ovary* superior, usually deeply lobed, 4–5-chambered; style simple; stigma truncate, capitate, or toothed. *Fruit* a capsule.

An African family of 3 genera, with about 30 species. Many species are reputed to have medicinal properties and are used by the natives for this purpose.

33. Melianthus major, Linn.

A herbaceous plant up to 1.5 m. high. *Leaves* 0.30 cm. or more long, pinnately compound; leaflets in 2 pairs, 15 cm. long, 5 cm. broad, oblong, sharply toothed, glabrous; rhachis winged; stipules 5–7.5 cm. long,

Plate XVII.

Adenia Digitata. Engl.

acuminate from a cordate base. *Flowers* in dense racemes 30 cm. or more long. *Bracts* ovate, acuminate, equalling the flower stalks. *Calyx* coloured and conspicuous; the odd sepal spurred. *Petals* 4, narrow. *Gland* 1.3 cm. long, adnate to the odd sepal. *Stamens* 4, of unequal lengths. *Ovary* 4-chambered. *Fruit* a membranous capsule, 2.5–3.5 cm. long, 4-winged.

A common plant throughout the south-western portion of the Cape Province. Known as "kruidjie- (or truidjie-) roer-my-nie."

Fatal effect on sheep drenched with a decoction of the leaves.

PASSIFLORACEAE.

Herbs, shrubs, or trees, with various habit, often climbing and furnished with tendrils. *Leaves* alternate, rarely opposite, petioled, simple, lobed or palmately 3–7-foliate, very rarely pinnate, often glandular at the apex of the petiole; stipules 0 or in pairs. *Flowers* bisexual or unisexual, solitary, in racemes, or in cymose panicles, often showy. *Calyx-tube* with 3 to many lobes. *Petals* 0 or as many as the calyx-lobes. *Corona* simple or double, tubular or cut into erect or radiating threads, rarely 0. *Stamens* 3–5, rarely many; filaments free or connate. *Ovary* superior, 1-chambered, with the ovules attached to the wall of the ovary; styles or stigmas 3–5. *Fruit* a capsule or berry, dehiscent or indehiscent.

Genera 11, with about 400 species, natives of America, Africa, Australia, Madagascar, and New Zealand; 3 genera, with 16 species, occur in South Africa.

Several species in the family are known to contain narcotic substances.

34. Adenia digitata. Engl. (*National Herbarium No.* 2639).—[Plate XVII.]

A twining plant provided with tendrils and with large underground tubers. *Leaves* 8–14 cm. long, digitately 3–5-lobed; the middle lobe pinnatisect; the side lobes again lobed on one side only or pinnatilobed, more rarely almost entire; midrib prominent above and beneath, with 2 prominent glands on the upper side at the base of the lamina and with glands beneath at the base of each leaf-segment, glabrous; petiole 1.3–1.7 cm. long, 6–7 mm. broad, flat above, convex beneath. *Calyx* tubular, 8.2 cm. long; lobes ovate, obtuse, glabrous; two lobes with lacerated margins. *Petals* 9 mm. long, obovate, shortly ciliate. *Filaments* united and glandular at the base. *Corona* represented by a fimbriated rim. *Fruit* fleshy, 3.5 cm., 2.5 cm. in diameter, reddish-yellow.

Recorded from the Pretoria, Waterberg, and Barberton districts of the Transvaal. The tubers contain two extremely violent poisons, and have caused death in humans.

RUBIACEAE.

Herbs, shrubs, or trees. *Leaves* simple, opposite or whorled. *Stipules* various, usually between the petioles. *Flowers* bisexual, rarely unisexual, usually regular. *Calyx* entire, toothed or lobed, sometimes with 1 or more of the lobes produced and foliaceous. *Corolla* various, naked or hairy within, usually equal. *Stamens* as many as the corolla-lobes. *Ovary* inferior, 1–10-chambered, very often 2-chambered; style simple, or styles free. *Fruit* a capsule, drupe, or berry.

Genera 395, with over 5,000 species especially abundant in tropical countries; 37 genera, with almost 180 species, occur in South Africa.

Many species in the family are considered to be poisonous.

35. Vangueria pygmaea, Schltr.—[Plate XVIII.]

An acaulescent plant with the leaves more or less tufted. *Leaves* opposite, about 5 cm. long, 0.9–1.8 cm. broad, obovate, rounded at the apex, narrowed at the base, hairy. *Flowers* in short rather dense axillary cymes. *Calyx* 7 mm. long, with a bell-shaped tube and long linear lobes. *Petals* hairy without, with a ring of hairs in the throat of the tube. *Stamens* 5. *Ovary* inferior; stigma mitraeform. *Fruit* a large drupe.

Common in parts of the Pretoria district. Known as the "witappeltjie" or "gousiektebossie."

Produces a disease in sheep known as "gousiekte."

SOLANACEAE.

Herbs, erect or climbing shrubs, more rarely trees, glabrous, pubescent, or stellately hairy, sometimes spiny. *Leaves* alternate, opposite, or whorled, entire or variously divided. *Inflorescence* cymose, sometimes reduced to one flower. *Flowers* bisexual, usually regular. *Calyx* usually 4–5-toothed or lobed. *Corolla* tubular, funnel-shaped, campanulate, or rotate, usually 4–5-lobed. *Stamens* as many as the corolla lobes and inserted on the corolla-tube. *Ovary* superior, usually 2-chambered; style filiform. *Fruit* a capsule or berry.

Genera about 66, with about 1,400 species: most abundant in South America; 8 genera, with almost 60 species, are recorded from South Africa.

The family contains several species of economic value, such as tobacco, potato, tomato, Cape gooseberry, etc., but the majority of the species are looked upon as poisonous. The alkaloid solanin is generally present. The deadly night-shade (*Atropha belladonna*), black henbane (*Hycocyanus niger*), are two well-known examples of poisonous plants in the family *Solanaceae*.

36. Datura stramonium, Linn.—[Plate XIX.]

A robust erect annual. *Leaves* up to 20 cm. long, 9.5 cm. broad, ovate, more or less coarsely toothed or lobed, acuminate at the apex, unequal at the base, with the veins prominent, glabrous; petiole 2.5–6 cm. long. *Flowers* solitary, large, up to 10 cm. long. *Calyx* tubular, with ovate-acuminate lobes. *Stamens* 5, included in the corolla-tube. *Ovary* superior, 4-lobed. *Fruit* large, spiny.

Common as a weed throughout the country. Commonly known as the "stinkblaar," "olieblaar," or "thorn apple."

The seeds contain hyocyamine, the active principle of henbane. Cases of human poisoning due to eating bread made from meal containing seed of this plant have been recorded by the Health Department.

37. Solanum nigrum, Linn.

A herbaceous annual. *Leaves* up to 10 cm. long, up to 5 cm. broad, ovate, obovate, or lanceolate, sinuate-toothed, tapering into the petiole; petiole up to 2.5 cm. long. *Flowers* in few-flowered axillary umbellate cymes. *Pedicels* spreading in the flowering stage, pendulous in the fruiting stage. *Calyx* cup-shaped; lobes ovate, acute. *Corolla* white, about 5 mm. long; lobes oblong-lanceolate. *Stamens* 5; anthers opening by 2 oblique pores near the apex. *Ovary* superior; style hairy below. *Fruit* a small globose black berry about the size of a pea.

Widely distributed as a weed in South Africa. Locally known as the "black night shade" or "nastergal."

The plant contains the alkaloids solanin and solanidin. The ripe fruits are often used for jams, but the unripe fruits are poisonous (*The Hawaiian Forester and Agriculturist*, March, 1920).

STIGMA
BUD
COROLLA OPENED
SEED
FRUIT
CROSS SECTION OF FRUIT
Vangueria pygmæa, Schltk.
Kathleen Alexander.

Plate XVIII.

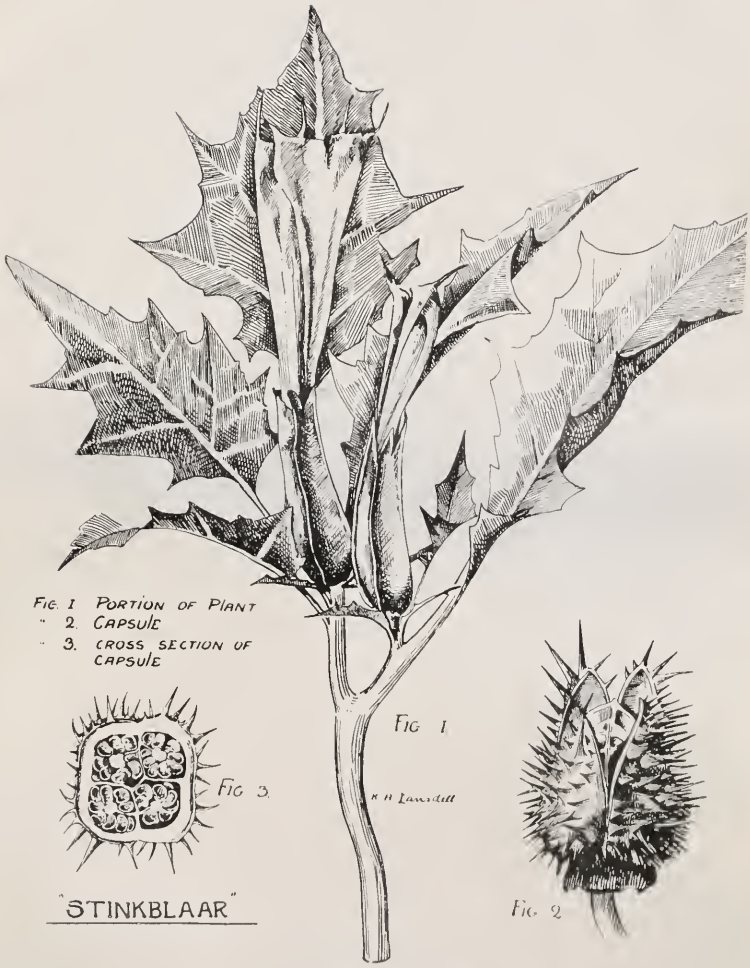

Plate XIX.] *Datura Stramonium.* [*K. A. Lansdell.*

STERCULIACEAE.

Herbs, shrubs, or trees, commonly with stellate hairs. *Leaves* alternate, very rarely sub-opposite, simple, entire, lobed, or digitately 3–9-foliate. *Stipules* usually present. *Flowers* in axillary or terminal umbels, racemes, panicles, or solitary, regular, bisexual or unisexual. *Epicalyx* present or absent. *Calyx* usually 5-lobed. *Petals* 5, free, rarely 0. *Stamens* as many as the petals, sometimes twice as many or several times as many; filaments connate at the base. *Gynaecium* superior, often of 2–5 more or less free carpels, very rarely of 10–12 carpels, or carpels reduced to one; style entire or divided. *Fruit* dry or rarely fleshy, often dividing into dehiscent or indehiscent carpels.

Genera 51, species about 700, abundant in South Africa and Australia.
The family is not considered a poisonous one.

38. Hermannia pauciflora, Turcz. (*National Herbarium No.* 1655.)

A bush, up to 30 cm. or more high, with the leaves more or less massed at the lower portion of the stem; the portion of the stem bearing the flowers more or less naked. *Leaves* 3.5–4.5 cm. long, pinnatifid; petiole up to 3 cm. long; leaf-lobes oblong, obtuse, glabrous or with scattered bundles of star-shaped hairs. *Flowers* in racemes at the ends of the naked stems, usually in pairs. *Calyx* 6–7 mm. long, somewhat membranous, with a bell-shaped tube and ovate-acuminate lobes. *Petals* free, 1 cm. long. *Stamens* 5; filaments short; anthers about as long as the petals. *Ovary* minutely glandular; style just exserted beyond the petals; stigma capitate.

Recorded from the Fraserburg and Carnarvon districts of the Cape Province. Known under the names of "skittery bossie," "Goewernement's bossie."
Causes severe purging in sheep and goats.

Hermannia brachypetala, Harv. (*National Herbarium No.* 2883.)

A sub-woody plant, with long lax semi-prostrate stems. *Leaves* sub-distant on the stems, 0.8–1.5 cm. apart; stipules linear; petiole 0.3–1 cm. long, hairy with star-shaped hairs; blade 0.8–3 cm. long, elliptic, obtuse, toothed on the upper half, with the veins prominent beneath, densely hairy beneath with stellate hairs, more sparsely hairy above. *Flowers* solitary, axillary on slender peduncles up to 3.5 cm. long. *Calyx-tube* shallow; lobes long, acuminate; both tube and lobes hairy with star-shaped hairs. *Petals* free, elliptic, shorter than the calyx-lobes. *Stamens* 5; filaments short; anthers produced into acuminate points and about as long as the calyx-lobes. *Ovary* densely hairy with stellate hairs; style longer than the anthers.

Recorded from the Barkly West district, parts of Bechuanaland, and the western Transvaal.
Feeding tests have shown that this species is injurious to stock, but not necessarily fatal.

THYMELAEACEAE.

Trees or large or small shrubs, with tough fibrous bark, rarely herbs. *Leaves* opposite or alternate, entire, small and heath-like or broader. *Inflorescence* usually a terminal sessile or stalked head, short raceme, or spike, rarely with flowers axillary and solitary. *Flowers* bisexual, *Perianth* 4–5-lobed, often inflated below, with 4–12 scales in the throat,

Plate XX. *K. A. Lansdell.*

Tribulus Terrestris. Linn.

or naked. *Stamens* 4–10, attached to the perianth-tube. *Ovary* superior, 1–2-chambered, with a singel ovule in each chamber ; style long or short ; stigma capitate, penicillate, or small. *Fruit* dry or fleshy.

Genera about 40, with about 400 species ; 10 genera, with about 170 species, occur in South Africa.

Several species in the family are known to contain poisonous substances.

39. Gnidia tomentosa, Eckl. (*Lasiosiphon anthylloides,* Meisn.)

A shrub, 0.3–2 m. high. *Branchlets* hairy. *Leaves* closely covering the branches, 1–2.2 cm. long, 2–5 mm. broad, lanceolate, sub-acute, densely silky with long hairs. *Flowers* in terminal heads, surrounded by the upper leaves. *Perianth-tube* 1.5 cm. long, narrow, tubular, more or less suddenly expanded into 5 lobes 3 mm. long ; tube and lobes densely silky. *Stamens* 10, in two rows, sessile on the upper portion of the perianth-tube. *Ovary* inferior ; style slender, rarely as long as the perianth-tube ; stigma capitate.

Widely distributed in South Africa, being recorded from the Riversdale, George, Knysna, Humansdorp, Uitenhage, Port Elizabeth, Albany, Bathurst, Kingwilliamstown, Komgha, Graaff-Reinet districts of the Cape Province, also recorded from the Pretoria district and from Natal and Zululand.

An infusion given as a drench produces diarrhoea in sheep and eventually death.

ZYGOPHYLLACEAE.

Herbs, shrubs, or undershrubs, rarely trees. *Leaves* often fleshy, usually opposite, usually 2-foliate, more rarely 3-foliate or pinnate. *Stipules* persistent, sometimes spinescent. *Flowers* usually pedunculed, solitary or 2-nate, bisexual, rarely unisexual, regular or irregular. *Sepals* usually 5. *Petals* usually 5, more rarely 4 or 0, free. *Stamens* as many as or twice as many as the petals, rarely 3 times as many. *Ovary* superior, usually 4–5-chambered ; style simple, or more rarely styles free. *Fruit* usually a capsule, rarely a drupe.

Genera 27, with over 100 species, principally in the tropics and warm regions of the northern and southern hemispheres ; 8 genera, with about 40 species, occur in South Africa.

The family is not considered a "poisonous" family.

40. Tribulus terrestris, Linn.—[Plate XX.]

An annual herb with prostrate branches. *Branches* hairy, with lax hairs. *Leaves* 1.5–5 cm. long, pinnately compound ; leaflets in 5–7 pairs, 0.5–1.5 cm. long, 2.5–4.5 mm. broad, oblong, obtuse at the apex, unequal at the base, sparsely hairy above, densely hairy beneath. *Flowers* usually large and showy, solitary in the axils of the leaves, on peduncles up to 3.5 cm. long. *Sepals* 5 mm. long, free to the base, densely hairy. *Petals* free, up to 2.3 cm. long, 1.8 cm. broad above, obovate. *Stamens* 10. *Ovary* covered with long stiff hairs. *Fruit* breaking up into five nutlets, each armed with 2 spines.

Common as a weed throughout the country. Commonly known as "dubbeltjie doring," "duiweltjies," and "volstruisdoring."

The plant produces a disease in sheep known as "geeldikkop."

GLOSSARY OF BOTANICAL TERMS USED.

Acaulescent : without an evident stem.
Achene : a small one-seeded fruit.
Bipinnate : when the leaflets of a leaf are again divided.
Carpel : portion of the gynaecium and consisting of an ovary, style, and stigma.
Corolla : is composed of a number of petals, which may be either all free or joined.
Corona : a structure found inside the corolla and often on the corolla itself.
Corymb : an inflorescence resembling a raceme, but the flowers more or less standing at the same level.
Culm : stalk of a grass.
Cyme : an inflorescence in which the terminal bud develops into a flower.
Dichotomous . a form of branching when the branches fork and each branchlet again forks.
Disc : an annular or glandular structure found inside the corolla.
Drupe : a succulent fruit containing a "stone."
Epicalyx : a whorl of leaf-like structures, often found at the base of the calyx in the *Malvaceae.*
Follicle : a fruit resembling a pod, but which opens along one margin only.
Gynaecium : the female organ of a flower composed of one or more carpels.
Inferior : a term applied to the ovary when it is situated below the calyx and corolla.
Inflorescence : a collection of flowers.
Involucral bracts : leaf-like structures which surround a head of flowers.
Ligule : a membranous or ciliated structure at the junction of the leaf-blade and leaf-sheath of grasses.
Node : the point on a stem from which one or more leaves arise.
Ovary : part of the female organ. It may be one- or more-chambered and contains the ovules. The ovary develops into the fruit and the ovules into the seed.
Ovule : small bodies in the ovary and which develop into the seed.
Palea : stiff chaff like structures, usually found on the receptacle or fruit of the Compositae.
Palmate : when the lobes of the leaves radiate from the base upwards.
Panicle : resembles a raceme, but the common peduncle is branched.
Pappus : name given to a collection of bristles or paleae on the fruits of the Compositae.
Peduncle : the stalk of an inflorescence.
Petiole : the stalk of a leaf.
Pinnate : when the leaf is cut into leaflets down to the common rhachis.
Pinnatisect : when a leaf is cut into segments almost to the mid-rib.
Raceme : an inflorescence in which the flowers are stalked on a common peduncle.
Radical : a term applied to leaves when they arise at the ground level.
Receptacle : the expanded apex of a peduncle on which the flowers are seated.
Rhachis : the common stalk of a compound pinnate leaf on which the leaflets are situated.
Stamens : the male organs of a flower, usually composed of a thread-like filament and an anther containing the pollen.
Stigma : the portion of the style which is receptive to the pollen-grains.
Stipules : small, often leaf-like bodies at the base of the leaf petiole.
Style : usually a cylindric structure from the ovary and bearing the stigma or stigmas at its apex.
Spathe : a structure subtending an inflorescence or a flower.
Superior : a term applied to the ovary when it is situated within the calyx and corolla.
Umbel : an inflorescence in which the flowers are stalked and are seated at the apex of a common peduncle.

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